A COMPUTER SYSTEM FOR SCHEDULING FIRE USE

PART I: THE SYSTEM

Larry S. Bradshaw and William C. Fischer

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RESEARCH SUMMARY

This report describes a user-oriented computer system that allows fire managers to quickly and easily analyze climatological data for the purpose of predicting the probable occurrence of desired conditions for prescribed fire. Two separate computer programs, RXWTHR and RXBURN, make up the system. Both programs are designed to use National Fire Weather Data Library climatological data. Among the features of these programs are: adjustment of fuel moistures from the weather station site to the fire site; a newly developed duff moisture model; and the capability to simultaneously consider up to 15 prescription factors.

Step-by-step instructions for use of the programs are given and demonstration runs are provided. Documentation of all programs is included. A computer terminal operator's manual for programs RXWTHR and RXBURN has been published as a separate General Technical Report (Bradshaw and Fischer 1981).

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INTRODUCTION

The timely occurrence of desired burning conditions has been and continues to be a major source of uncertainty associated with using fire as a resource management tool. Although such uncertainty cannot be eliminated, it can be reduced by using information contained in climatological records (Fischer 1978); for example, analysis of climatological data can describe an area's average weather and also likely deviations from this average situation. A fire manager can use such information to identify periods when desired burning conditions might occur. Further analysis can result in calculation of the probability of desired fire conditions occurring during the periods identified (Furman 1979).

The value of climatological analysis as an aid for scheduling prescribed fires can be summarized as follows:

1. Prescribed fire schedules can be geared to the number of probable burning days. Over-scheduling of fires, especially during traditional burning periods, can be minimized.

2. Prescribed fire opportunities outside traditional burning periods can be identified insofar as available weather data will allow.

3. Project priorities can be more nearly matched to the probable occurrence of prescribed conditions. Some fires require a narrow range of burning conditions for successful accomplishment. These fires can be given top priority for scheduling during periods when such conditions are most likely to occur.

4. Fire management prescriptions for preplanned use of chance wildfires can be evaluated before they are implemented. The frequency and time of occurrence of prescribed fire conditions can be identified. This information can then be used to evaluate the probable impact of the prescription and then compared with the probable performance of alternative prescriptions.

Despite its obvious value, fire managers rarely have had the means to easily analyze climatological data when planning fire use. This is due, in part at least, to the tedious nature of the task. It is also due, in part, to weather data problems: missing data, lack of data during spring and fall, and, in some cases, unreliable data resulting from poor observation and poor weather station maintenance.

This report describes a user-oriented computer system that allows fire managers to quickly and easily analyze climatological data for the purpose of predicting the probable occurrence of desired prescribed fire conditions. Instructions are provided to assist both the fire manager and the computer specialist through the various steps required to use the system. Finally, documentation of the computer programs used is provided. A computer terminal operator's manual has been published as a separate report (Bradshaw and Fischer 1981).

SYSTEM DESCRIPTION

Two separate, but interrelated computer programs, RXWTHR (Prescribed Fire Weather) and RXBURN (Prescribed Fire Conditions) make up the system. Both programs are designed to use the climatological data base stored in the National Fire Weather Data Library (NFWDL) (Furman and Brink 1975), which is located at the USDA Forest Service's Fort Collins Computer Center (FCCC). RXWTHR and RXBURN are stored in the Region 1 program library at FCCC and are available via remote terminal or batch processing to all who have access to FCCC facilities.

Information Provided by the programs

Program RXWTHR provides climatological summaries and co-occurrence frequencies of user-selected fire weather and fire danger rating parameters. The 16 parameters available for analysis are:

1. State of the weather
2. Temperature
3. Relative humidity
4. Wind direction
5. Wind speed
6. Maximum temperature (last 24 hours)
7. Minimum temperature (last 24 hours)
8. Maximum relative humidity (last 24 hours)
9. Minimum relative humidity (last 24 hours)
10. Precipitation duration
11. Precipitation amount (last 24 hours)
12. 1 hour fuel moisture
13. 10 hour fuel moisture
14. 1978 National Fire Danger Rating System (NFDRS) Energy Release Component (ERC) (with selected fuel models)
15. NFDRS Burning Index (BI) (with selected fuel models)
16. Duff Moisture (24-hour average for entire layer)

The user is reminded that Program RXWTHR can be used to summarize and analyze only those parameters that are included in NFWDL for the weather station of interest. The importance of maintaining complete records at the NFWDL and keeping them current through the Adminstrative and Forest Fire Information Retrieval and Management System (AFFIRMS) (Helfman and others 1975) cannot be overly stressed.

Examples of the type of information provided by RXTHWR are shown in figures 1, 2, 3, and 4.

10 DAY AND MONTHLY SUMMARIES OF ***TEMPERATURE ***

RELATIVE FREQUENCY OF OCCURRENCE OF DAILY VALUES (1500 MST)

DEMONSTRATION OF RXWTHR OUTPUT FOR PHILLIPSBURG RANGER STATION

PHILLIPSBURG RS (243002) 1960-1977

TEMPERATURE (F)

PERIOD BEGINS	BELOW 55	55 TO 59	50 TO 54	65 TO 69	70 TO 74	75 TO 79	80 TO 84	85 TO 89	90 TO 94	95 AND ABOVE	N. DAYS	MEAN	SD	MEDIAN	RANGE
MAY 1	53.8	12.5	11.5	12.5	2.9	6.7					104	54.3	11.5	52.6	34 - 79
MAY 11	39.4	17.4	14.7	12.8	9.2	6.4					109	57.3	11.0	57.0	30 - 79
MAY 21	31.4	19.6	20.3	12.7	11.0	5.1	.8				118	59.1	10.3	59.0	33 - 84
JUN 1	21.8	14.5	13.6	21.8	15.4	9.1	2.7				110	62.8	9.8	64.0	39 - 82
JUN 11	25.7	16.5	7.3	18.3	13.8	10.1	3.7	4.6			109	63.3	11.8	64.1	34 - 88
JUN 21	13.2	12.3	9.4	15.1	19.8	13.2	12.3	4.7			106	67.7	11.6	69.0	38 - 87
JUL 1	1.4	5.8	5.8	12.3	20.3	29.0	19.6	5.1		.7	139	73.8	8.0	74.8	52 - 95
JUL 11	1.3	5.3	6.7	11.3	15.3	23.3	22.0	11.3	3.3		150	75.1	9.1	76.1	48 - 92
JUL 21	.6	1.2	4.9	8.5	10.9	23.6	29.7	19.4	1.2		165	78.0	7.5	79.1	52 - 90
AUG 1	1.9	4.4	3.8	12.6	16.4	20.1	21.4	15.1	3.8	.6	159	76.4	9.2	76.7	50 - 95
AUG 11	2.1	4.1	5.2	9.6	13.0	19.9	23.3	21.2	.7		145	76.5	9.3	77.8	45 - 91
AUG 21	11.3	8.1	9.1	11.9	13.1	22.5	15.6	6.9	1.9	.6	160	70.8	11.6	73.0	41 - 95
SEP 1	23.1	7.7		15.4	30.8		7.7	7.7	7.7		13	67.4	14.7	69.6	45 - 90
MAY	41.1	15.3	15.7	12.7	7.9	6.0	.3				331	57.0	11.1	56.7	30 - 84
JUN	20.3	14.5	10.2	18.5	16.6	10.8	6.2	3.1			325	64.6	11.3	65.4	34 - 88
JUL	1.1	4.0	5.7	10.6	15.2	25.2	24.1	12.4	1.5	.2	453	75.8	8.4	76.7	48 - 95
AUG	5.2	5.6	6.0	11.4	14.2	20.9	20.0	14.2	2.2	.4	465	74.5	10.5	75.8	41 - 95
SEP	23.1	7.7		15.4	30.8		7.7	7.7	7.7		13	67.4	14.7	69.6	45 - 90

Figure 1.--Example of Program RXWTHR summary table for temperature.

10 DAY AND MONTHLY SUMMARIES OF ***WIND DIRECTION ***

RELATIVE FREQUENCY OF OCCURRENCE OF DAILY VALUES (1500 MST)

DEMONSTRATION OF RXWTHR OUTPUT FOR PHILLIPSBURG RANGER STATION

PHILLIPSBURG RS (243002) 1960-1977

WIND DIRECTION

PERIOD BEGINS	CALM	NE	E	SE	S	SW	W	NW	N	N. DAYS	MODE
MAY 1	1.9	8.7	1.9	1.9	2.9	26.9	19.2	28.8	7.7	104	NW
MAY 11	1.8	9.3	1.8	1.8	1.8	22.9	20.2	27.5	13.8	109	NW
MAY 21	.8	3.4	.8	2.5	.8	29.7	12.7	39.1	11.0	118	NW
JUN 1	5.5	5.5	3.6	4.5		18.2	14.5	39.1	9.1	110	NW
JUN 11	3.7	1.8	4.6	3.7	1.8	26.6	12.8	30.3	14.7	109	NW
JUN 21	5.7	4.7	2.8	1.9	3.8	25.5	17.9	26.4	11.3	106	NW
JUL 1	2.9	5.8	2.2	2.9	.7	25.4	15.9	29.7	14.5	138	NW
JUL 11	3.3	5.3	2.0	2.0	7.3	22.0	15.3	27.3	15.3	150	NW
JUL 21	1.2	4.8	1.2	2.4	3.0	20.6	20.0	37.6	9.1	165	NW
AUG 1	1.9	9.4	1.3	4.4	1.9	30.2	12.6	30.8	7.5	159	NW
AUG 11	2.7	1.4	1.4	1.4	1.4	28.1	17.8	39.7	6.2	146	NW
AUG 21	2.5	3.8	.6	2.5	9.8	23.1	18.8	32.5	7.5	160	NW
SEP 1					7.7	15.4	46.2	30.8		13	W
MAY	1.5	6.6	1.5	2.1	1.8	26.6	17.2	31.7	10.9	331	NW
JUN	4.9	4.0	3.7	3.4	1.8	23.4	15.1	32.0	11.7	325	NW
JUL	2.4	5.3	1.9	2.4	3.8	22.5	17.2	31.8	12.8	453	NW
AUG	2.4	4.9	1.1	2.8	4.1	27.1	16.3	34.2	7.1	465	NW
SEP					7.7	15.4	46.2	30.8		13	W

Figure 2.--Example of Program RXWTHR summary table for wind direction.

WIND DIRECTION - WIND SPEED

PERCENT FREQUENCY OF CO-OCCURRENCE
GIVEN TO TENTHS PERCENT

PHILLIPSBURG RS (243002) 1960-1977

DEMONSTRATION OF RXWTHR OUTPUT FOR PHILLIPSBURG RANGER STATION

** MAY **

	WIND SPEED MPH											
DIR	BELOW 3	3 TO 5	6 TO 8	9 TO 11	12 TO 14	15 TO 17	18 TO 20	21 TO 23	24 TO 27	28 AND ABOVE	TOTAL	
CALM	1.5										1.5	
NE	2.7	1.8	.3	1.2		.3		.3			6.6	
E	.3	.6	.3		.3						1.5	
SE	.3	.9	.6		.3						2.1	
S	.3	.3	.3	.9							1.8	
SW	.9	9.7	5.1	4.2	3.6	2.1	.9				26.6	
W	1.8	1.8	6.6	2.4	3.6	.9					17.2	
NW	1.5	9.4	7.9	4.8	3.6	3.6	.6	.3			31.7	
N	.3	1.5	3.3	3.0	1.8	.6	.3				10.9	
TOTAL	9.7	26.0	24.5	16.6	13.3	7.5	1.8	.6	0.	0.	100.0	NUMBER OF DAYS 331

** JUN **

	WIND SPEED MPH											
DIR	BELOW 3	3 TO 5	6 TO 8	9 TO 11	12 TO 14	15 TO 17	18 TO 20	21 TO 23	24 TO 27	28 AND ABOVE	TOTAL	
CALM	4.9										4.9	
NE	.3	1.8	.6	.9	.3						4.0	
E	.3	.9	1.2	.9	.3						3.7	
SE	.6	1.2	.6	.3		.6					3.4	
S		.9	.3		.6						1.8	
SW	4.9	6.5	3.1	4.3	1.8	1.2	1.5				23.4	
W	.6	4.6	2.8	3.1	3.7	.3					15.1	
NW	2.8	7.7	8.9	6.8	4.9	.6	.3				32.0	
N	.3	2.2	4.0	1.5	.9	2.5			.3		11.7	
TOTAL	14.8	25.8	21.5	17.8	12.6	5.2	1.8	0.	.3	0.	100.0	NUMBER OF DAYS 325

Figure 3.--Example of Program RXWTHR two-way co-occurrence table for wind direction and windspeed.

TEMPERATURE - RELATIVE HUMIDITY - WIND SPEED

PERCENT FREQUENCY OF CO-OCCURRENCE, GIVEN TO TENTHS PERCENT

PHILLIPSBURG RS (243002)
** MAY ** 1960-1977

DEMONSTRATION OF RXWTHR OUTPUT FOR PHILLIPSBURG RANGER STATION

WIND SPEED LT 6 MPH

TEMP (F)	RELATIVE HUMIDITY % BELOW 10	10 TO 19	20 TO 29	30 TO 39	40 TO 49	50 TO 59	60 TO 69	70 TO 79	80 TO 89	90 AND ABOVE
LT 55				.6	1.5	3.6	1.2	3.3	2.4	3.0
55 - 59			.6	.6	2.4	1.2	.6		.3	
60 - 64			.6	1.8	1.8	.6	.3	.3		
65 - 69			1.2	2.1	.6		.3			
70 - 74		.6	.9	.6		.3				
75 - 79		.3	1.2		.3					
80 - 84		.3								
85 - 89										
90 - 94										
GE 95										
TOTAL	0.	1.2	4.5	5.7	6.6	5.7	2.4	3.6	2.7	3.0

WIND SPEED 6 - 11 MPH

TEMP (F)	RELATIVE HUMIDITY % BELOW 10	10 TO 19	20 TO 29	30 TO 39	40 TO 49	50 TO 59	60 TO 69	70 TO 79	80 TO 89	90 AND ABOVE
LT 55			.3	1.2	3.3	2.4	3.6	3.0	2.1	.9
55 - 59		.6	1.2	3.3	1.2	.3	.3			
60 - 64		.3	1.5	2.7	.6	.9				
65 - 69		.6	1.8	1.2	.9					
70 - 74		.3	2.1	.9	.3					
75 - 79		1.5	1.2	.3						
80 - 84										
85 - 89										
90 - 94										
GE 95										
TOTAL	0.	3.3	8.2	9.7	6.3	3.6	3.9	3.0	2.1	.9

WIND SPEED 12 - 17 MPH

TEMP (F)	BELOW 10	10 TO 19	20 TO 29	30 TO 39	40 TO 49	50 TO 59	60 TO 69	70 TO 79	80 TO 89	90 AND ABOVE
LT 55				.9	1.8	.9	1.5	1.2	.9	
55 - 59			.6	.9	.9	.6	.3			
60 - 64	.3		.9	1.2	.6		.3	.3		
65 - 69			.9	1.8	.3	.3		.3		
70 - 74			1.8							
75 - 79			1.2							
80 - 84										
85 - 89										
90 - 94										
GE 95										
TOTAL	.3	0.	5.4	4.8	3.6	1.8	2.1	1.8	.9	0.

WIND SPEED 18 - 23 MPH

TEMP (F)	BELOW 10	10 TO 19	20 TO 29	30 TO 39	40 TO 49	50 TO 59	60 TO 69	70 TO 79	80 TO 89	90 AND ABOVE
LT 55				.3	.3		.3	.3		
55 - 59				.3						
60 - 64				.3		.3				
65 - 69				.3						
70 - 74										
75 - 79										
80 - 84										
85 - 89										
90 - 94										
GE 95										
TOTAL	0.	0.	0.	1.2	.3	.3	.3	.3	0.	0.

WIND SPEED GE 24 MPH

TEMP (F)	BELOW 10	10 TO 19	20 TO 29	30 TO 39	40 TO 49	50 TO 59	60 TO 69	70 TO 79	80 TO 89	90 AND ABOVE
LT 55										
55 - 59										
60 - 64										
65 - 69										
70 - 74										
75 - 79										
80 - 84										
85 - 89										
90 - 94										
GE 95										
TOTAL	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

TEMP (F)	TOTAL
LT 55	41.1
55 - 59	16.3
60 - 64	15.7
65 - 69	12.7
70 - 74	7.9
75 - 79	6.0
80 - 84	.3
85 - 89	0.
90 - 94	0.
GE 95	0.
TOTAL	100.0

NUMBER OF DAYS 331

Figure 4.--Example of Program RXWTHR three-way co-occurrence table for temperature, relative humidity, and windspeed.

Program RXBURN provides analyses of local prescription condition frequencies based on user-defined prescription conditions. The 16 parameters available for use as prescription conditions are:

1. State of the weather
2. Temperature
3. Relative humidity
4. Wind direction
5. Wind speed

6. Maximum temperature (last 24 hours)

7. Minimum temperature (last 24 hours)

8. Maximum relative humidity (last 24 hours)

9. Minimum relative humidity (last 24 hours)

10. Number of days since last measurable precipitation

11. Precipitation amount (last 24 hours)

12. 1 hour fuel moisture

13. 10 hour fuel moisture

14. 1978 NFDRS ERC (with selected NFDRS fuel models)

15. 1978 NFDRS BI (with selected NFDRS fuel models)

16. Duff moisture (24-hour average for entire layer).

As many as 15 of these parameters may be used in a single prescription. Information provided by RXBURN is exemplified in figures 5, 6, 7, and 8.

PROGRAM RXBURN: RUN NO. 1 DISTRICT: FIRELAB FOREST: MONTANA PAGE NO. 1

DEMONSTRATION OF RXBURN OUTPUT FOR PHILLIPSBURG RANGER STATION

AFFIRMS STATION NAME: PHILLIPSBURG RS NATIONAL FOREST: MONTANA
STATION NUMBER: 243002 DISTRICT: FIRELAB
ELEVATION FT MSL: 5280 USER: BRADSHAW

YEARS OF WEATHER DATA REQUESTED: 1950 TO 1977 (18 YEARS)
SEASONAL DATES OF ANALYSIS : MAY 1 TO NOV 1
TOTAL DAYS AVAILABLE : 2215 DAYS OVER 16 YEARS

PRESCRIPTION FACTOR SUMMARY

PRESCRIPTION FACTORS	PREFERABLE CONDITIONS		ACCEPTABLE CONDITIONS	
	MINIMUM	MAXIMUM	MINIMUM	MAXIMUM
1. TEMPERATURE (DEG F)	65	75	60	80
2. RELATIVE HUMIDITY (%)	20	30	20	55
3. WIND SPEED (MPH)	4	9	0	15

PRESCRIPTION OCCURRENCE SUMMARY

	PREFERABLE	ACCEPTABLE	UNACCEPTABLE
DAYS PER SEASON WITHIN PRESCRIPTION	8	51	80
(PERCENT)	5%	37%	58%
MONTH OF HIGHEST PRESCRITION FREQUENCY	SEP	JUL	OCT
(PERCENT PROBABILITY)	9%	45%	71%
10 DAY PERIOD OF HIGHEST RX FREQUENCY BEGINS	JUN 1 OCT 1	JUL 1	MAY 1
(PERCENT PROBABILITY)	10%	57%	78%

Figure 5.--Example of Program RXBURN summary table.

PRESCRIPTION OCCURRENCE BY 10 DAY PERIOD AND MONTH

MONTH	PERIOD BEGINS	NO. DAYS	** PREFERABLE DAYS ** MEAN	NUMBER	PERCENT	** ACCEPTABLE DAYS ** MEAN	NUMBER	PERCENT	** UNACCEPTABLE DAYS ** MEAN	NUMBER	PERCENT
MAY	1	104	0	5	5%	1	18	17%	5	81	78%
MAY	11	109	0	5	5%	2	33	30%	4	71	65%
MAY	21	118	1	8	7%	3	40	34%	4	70	59%
MAY	TOTAL	331	1	18	5%	6	91	27%	14	222	67%
JUN	1	110	1	11	10%	3	50	45%	3	49	45%
JUN	11	109	0	4	4%	2	39	36%	4	66	61%
JUN	21	106	0	6	6%	3	45	42%	3	55	52%
JUN	TOTAL	325	1	21	6%	8	134	41%	11	170	52%
JUL	1	138	0	3	2%	5	78	57%	4	57	41%
JUL	11	150	1	8	5%	4	62	41%	5	80	53%
JUL	21	165	0	5	3%	4	63	38%	6	97	59%
JUL	TOTAL	453	1	16	4%	13	203	45%	15	234	52%
AUG	1	159	0	7	4%	4	66	42%	5	86	54%
AUG	11	146	0	3	2%	4	56	38%	5	87	60%
AUG	21	160	1	10	6%	4	67	42%	5	83	52%
AUG	TOTAL	465	1	20	4%	12	189	41%	16	256	55%
SEP	1	137	1	12	9%	3	55	40%	4	70	51%
SEP	11	129	1	11	9%	3	45	35%	5	73	57%
SEP	21	117	1	11	9%	2	39	33%	4	67	57%
SEP	TOTAL	383	2	34	9%	9	139	36%	13	210	55%
OCT	1	90	1	9	10%	1	20	22%	4	61	68%
OCT	11	90	0	3	3%	1	21	23%	4	66	73%
OCT	21	78	0	0	0%	1	22	28%	4	56	72%
OCT	TOTAL	258	1	12	5%	4	63	24%	11	183	71%
NOV	TOTAL	0	0	0	0%	0	0	0%	0	0	0%
TOTAL	TOTAL	2215	8	121	5%	51	819	37%	80	1275	58%

Figure 6.--Example of Program RXBURN prescription frequency of occurrence table.

PRESCRIPTION RUN LENGTH SUMMARY

MONTH	PERIOD BEGINS	** PREFERABLE DAY RUNS ** * PERCENTILES * MEAN	25TH	MEDIAN	75TH	** ACCEPTABLE DAY RUNS ** * PERCENTILES * MEAN	25TH	MEDIAN	75TH	** UNACCEPTABLE DAY RUNS ** * PERCENTILES * MEAN	25TH	MEDIAN	75TH
MAY	1	3	1	1	4	1	1	1	2	4	2	4	7
MAY	11	1	1	1	1	2	1	2	2	3	1	2	5
MAY	21	1	1	1	1	2	1	1	2	3	1	2	5
MAY	TOTAL	1	1	1	1	2	1	1	2	4	1	3	8
JUN	1	2	1	1	2	2	1	1	3	2	1	2	3
JUN	11	1	1	1	1	2	2	2	2	3	1	2	5
JUN	21	1	1	1	1	2	1	1	2	3	1	2	4
JUN	TOTAL	1	1	1	1	2	1	2	2	3	1	2	5
JUL	1	1	1	1	1	2	1	2	3	2	1	1	2
JUL	11	1	1	1	1	2	1	1	2	2	1	1	3
JUL	21	1	1	1	1	2	1	1	2	3	1	2	4
JUL	TOTAL	1	1	1	1	2	1	1	2	2	1	2	3
AUG	1	1	1	1	1	2	1	1	2	2	1	2	3
AUG	11	1	1	1	1	2	1	1	3	3	1	2	4
AUG	21	1	1	1	1	2	1	1	2	2	1	2	3
AUG	TOTAL	1	1	1	1	2	1	1	3	3	1	2	3
SEP	1	1	1	1	1	2	1	1	2	2	1	2	2
SEP	11	1	1	1	1	2	1	2	3	3	1	2	5
SEP	21	1	1	1	1	2	1	1	2	3	1	2	3
SEP	TOTAL	1	1	1	1	2	1	1	2	3	1	2	4
OCT	1	1	1	1	1	1	1	1	2	3	1	2	4
OCT	11	2	1	1	2	2	1	1	3	4	2	3	6
OCT	21	0	0	0	0	2	1	1	2	2	1	1	2
OCT	TOTAL	1	1	1	1	2	1	1	2	4	1	2	5
NOV	TOTAL	0	0	0	0	0	0	0	0	0	0	0	0

Figure 7.--Example of Program RXBURN prescription run length summary.

PROBABILITY OF MEETING PRESCRIPTION 1, 2, AND 3 DAYS IN THE FUTURE

MONTH: MAY

TODAYS COND	*** TOMORROW *** PREF	ACCP	UNAC	**** 2 DAYS **** PREF	ACCP	UNAC	**** 3 DAYS **** PREF	ACCP	UNAC		N DAYS
PREF	17%	50%	33%	9%	38%	53%	7%	32%	61%	PREF	18
ACCP	12%	47%	41%	8%	35%	56%	7%	31%	62%	ACCP	85
UNAC	2%	18%	80%	4%	24%	72%	5%	25%	68%	UNAC	216

MONTH: JUN

TODAYS COND	*** TOMORROW *** PREF	ACCP	UNAC	**** 2 DAYS **** PREF	ACCP	UNAC	**** 3 DAYS **** PREF	ACCP	UNAC		N DAYS
PREF	20%	60%	20%	10%	51%	39%	8%	45%	47%	PREF	20
ACCP	9%	56%	35%	8%	47%	45%	7%	43%	49%	ACCP	132
UNAC	3%	28%	69%	5%	37%	58%	6%	40%	54%	UNAC	173

MONTH: JUL

TODAYS COND	*** TOMORROW *** PREF	ACCP	UNAC	**** 2 DAYS **** PREF	ACCP	UNAC	**** 3 DAYS **** PREF	ACCP	UNAC		N DAYS
PREF	0%	75%	25%	4%	48%	49%	4%	45%	51%	PREF	16
ACCP	4%	52%	44%	4%	46%	51%	4%	45%	52%	ACCP	206
UNAC	3%	36%	61%	3%	43%	54%	4%	44%	52%	UNAC	227

Figure 8.--Example of program RXBURN prescription occurrence contingency table.

Information Needed to Use the Programs

Both programs require climatological data from the National Fire Weather Data Library. Information on the NFWDL data base structure and use is detailed by Furman and Brink (1975). For completeness, instructions for accessing NFWDL data for use in RXWTHR and RXBURN are outlined in the User's Guide in the next section of this report.

The user must also furnish information requested on the information worksheets for RXWTHR and RXBURN (figs. 9 and 10).

Project[1] _____

Fire weather station information Station name _____, No. _____

Elevation _____ ft, Latitude _____, Climate class[2] _____, Slope class[3] _____

Fuel model[4] _____, Last frost[5] _____, Grass type[5]: annual _____, perennial _____

Year begin _____, Year end _____, Date begin _____, Date end _____

Site Adjustment Factors (if any).

Aspect _____ (1=north, 2=east, 3=south, 4=west), Site elevation _____ ft.

Canopy cover _____ (1=open, 2=closed)

Duff/Soil Horizon Information if Duff Moisture selected. See User's Guide, appendix D):

Layer	Duff/Soil Type	Thickness
1	_____	____cm
2	_____	____cm
3	_____	____cm
4	_____	____cm
5	_____	____cm

1/ Use up to 80 characters

2/ See User's Guide, appendix C

3/ See User's Guide, appendix B

4/ For NFDRS indices only. See User's Guide, appendix A

5/ For NFDRS indices only

Summary Table(s) Requested (Select up to 15):

____State of the weather
____Temperature (degrees F)
____Relative humidity (%)
____Wind direction (8 point)
____Wind speed (mi/h)
____Max temperature (24 h, deg. F)
____Min temperature (24 h, deg. F)
____Max relative humidity (24 h, %)
____Min relative humidity (24 h, %)
____Precip duration (last 24 h)
____Precip amount (24 h, 0.01 in)
____1 hour fuel moisture (%)
____10 hour fuel moisture (%)
____NFDRS ERC
____NFDRS BI
____Duff Moisture (24 h average, %)

Co-occurrence Table(s) Requested (If 2-way table desired leave last space blank. If selected, Wind Direction must always be listed first.):

1 _____ with _____ with _____

2 _____ with _____ with _____

3 _____ with _____ with _____

4 _____ with _____ with _____

_____ with _____ with _____

Figure 9.--RXWTHR user information sheet.

RXBURN -- USER INFORMATION SHEET

Total Number Different Stations in This Run _____

User's Name _____, Subunit _____, Unit _____

Project[1/] _____

Fire Weather Station Information: Station name _____, No. _____

Elevation _____ ft., Latitude _____, Climate class[2/] _____, Slope class[3/] _____

Fuel model[4/] _____, Last frost[5/] _____, Grass type[5/]: annual _____, perennial _____

Year begin _____, Year end _____, Date begin _____, Date end _____

Site Adjustment Factors (if any):

Aspect _____ (1=north, 2=east, 3=south, 4=west), Site elevation _____ ft.

Canopy cover _____ (1=open, 2=closed)

Duff/Soil Horizon Information (if Duff Moisture selected. See User's Guide, Appendix D):

Layer	Duff/Soil Type	Thickness
1	_____	_____ cm
2	_____	_____ cm
3	_____	_____ cm
4	_____	_____ cm
5	_____	_____ cm

1/ Use up to 80 characters

2/ See User's Guide, appendix C

3/ See User's Guide, appendix B

4/ For NFDRS indicies only. See User's Guide, appendix A

5/ For NFDRS indices only

Prescription Factor Selections (Check and set limits for up to 15 factors.):

	Factor	Preferable Rx Minimum	Preferable Rx Maximum	Acceptable Rx Minimum	Acceptable Rx Maximum
____	State of the weather.....	_____	_____	_____	_____
____	Temperature (deg. F).....	_____	_____	_____	_____
____	Relative humidity (%).....	_____	_____	_____	_____
____	Wind direction (8 point).....	_____	_____	_____	_____
____	Wind speed (mi/h).....	_____	_____	_____	_____
____	Max temperature (24 h, deg. F).....	_____	_____	_____	_____
____	Min temperature (24 h, deg. F).....	_____	_____	_____	_____
____	Max relative humidity (24 h, %).....	_____	_____	_____	_____
____	Min relative humidity (24 h, %).....	_____	_____	_____	_____
____	Days since last precipitation.....	_____	_____	_____	_____
____	Precip amount (24 h, 0.01 in).....	_____	_____	_____	_____
____	1 hour fuel moisture (%).....	_____	_____	_____	_____
____	10 hour fuel moisture (%).....	_____	_____	_____	_____
____	NFDRS ERC.....	_____	_____	_____	_____
____	NFDRS BI.....	_____	_____	_____	_____
____	Duff moisture (24 h average, %).....	_____	_____	_____	_____

Figure 10.--RXBURN user information sheet.

Program Use

Ideally, the programs should be used sequentially. RXWTHR will give the manager a method for screening possible combinations of prescription factors to eliminate those which have a low probability of occurring simultaneously, as well as supplying a local fire climatological summary.

Once a feeling for the occurrence and timing of desired prescription conditions is reached, RXBURN may be used to provide a detailed summary of prescription occurrence frequencies.

Because of the costs involved, RXWTHR should be run as few times as possible for any given station, while RXBURN may be run many times for different prescriptions and planning processes. Each program is, however, completely independent of the other and sequential use is not mandatory.

Options and Features of the Programs

FORTRAN IV code is ASCII standard.

1978 National Fire Danger Rating System (NFDRS) algorithms and subroutines are used by the programs where applicable (Deeming and others 1977).

The routines operate on simple input streams.

The programs contain input error checks that print error messages.

The programs offer 1978 NFDRS indices, Energy Release Component (ERC) and Burning Index (BI) as prescription parameters based on NFDRS fuel models.

The programs contain site adjustment factors to adjust fuel moisture values (and resulting ERC's and BI's) to locations with elevations, aspects, and canopy covers different than those of the user-specified station.

RXWTHR allows as many as 15 summary tables and five co-occurrence tables to be produced in a single run.

RXBURN allows as many as 15 prescription factors to be simultaneously considered in a prescription condition.

As many as 99 fire weather stations may be analyzed for summaries or prescription occurrence in a single run.

Repeated runs of the same fire weather station allowing different prescription conditions to be analyzed in one run is possible through the construction of a disk file to hold first run computations.

A newly developed duff moisture model is available (Fosberg 1975).

RXBURN allows two prescription condition ranges to be entered for each prescription factor. One is an ideal or "preferable" burning condition, the other is an "acceptable" burning condition.

RXBURN allows the number of days since last precipitation as a prescription condition.

System Limitations

Programs RXWTHR and RXBURN are designed to use archival data in the National Fire Weather Data Library (Furman and Brink 1975). Gibson (1977) and others have noted a limitation in the use of National Fire Weather Data Library records for planning prescribed fire--observations are taken only once a day over the length of the fire season. This results in two constraints on any system that uses the data. First, the single observation must be considered to be representative of the entire day, when in fact it represents the "typical worst" conditions (midafternoon, southwest aspect, midslope, open canopy). Second, weather observations are rarely recorded for more than 5 months each year during the "fire season." Data therefore tend to be scarce in prefire and postfire season periods--times that prescribed fire operations are generally most active.

To reduce computer storage requirements, program RXWTHR analyzes a maximum of 5 months of weather data from the National Fire Weather Data Library in a single run. This is usually not a limitation of the system since few stations have more than 5 months of data on file for each year. For those stations with more than 5 months of fire weather data, two or three runs of RXWTHR may be needed to obtain the desired climatological summaries. The 5-month restriction does not apply to program RXBURN.

A newly developed duff moisture model is available for test use (Fosberg 1975). The model is based on theoretical considerations of water transport through the litter, duff, and soil horizons as affected by daily weather observations. The model is still in the validation stage, and results should be viewed as tentative and used with caution. Preliminary results indicate the model will consistently underestimate duff moisture content.

USER'S GUIDE

Step-by-step instructions for using RXWTHR and RXBURN follow. Demonstration runs of both programs are included to support these instructions. The instructions are written so that anyone familiar with the use of remote terminal or batch processing equipment should be able to successfully run the programs.

In organizations that employ computer technicians, the fire manager's role in running these programs may be limited to completing the user information sheets (figs. 9 and 10).

Create a Data File

Two items of information are needed to obtain data from the NFWDL. First is the six-digit code (or codes) of the fire weather station(s) to be analyzed and the years of data to be analyzed. Second is the file name in the library that contains the lowest station code that will be used in the analysis. For example, if the stations to be analyzed are 034567, 245789, and 003452, only the file name that contains station 003452 is needed.

Obtain a File Name

There is a possibility that a local fire weather officer or computer specialist has a current listing of the files in the library. If not, obtain a file list in the following manner:

```
         1         2         3         4         5
12345678901234567890123456789012345678901234567890


@RUN,...

@ASG,A FIREDATALIB*PROGRAMS.

@XQT FIREDATALIB*PROGRAMS.LISTFILES

@FIN
```

System software will then respond with a listing of file names and stations in the file. An example of the general format follows. (Note: ssssss represents the six-digit station code, and yy represents the last two digits of the year that data begins (FROM) or ends (THROUGH); nn, mm, and oo represent assorted numbers and letters of file names.)

FILE NAME	STATION YEAR LIMITS		DATE OF LAST
	FROM	THROUGH	UPDATE
FIREDATALIB*nn-mm	ssssssyy	ssssssyy	mmddyy
FIREDATALIB*oo	ssssssyy	ssssssyy	mmddyy

Scan the station year limits column until the group containing the lowest six-digit station code of stations to be analyzed is found. The entire file name (FIREDATALIB*mm-nn) is to be used in place of "FILE" in the following data acquisition sequence.

Create a Card Image File

In creating a card image file for use in RXWTHR or RXBURN, it is wise to generate a user program file of the data. This allows the data file to be stored in the Mass File Directory at FCCC for 6 days from the date of creation, allowing subsequent runs of RXWTHR or RXBURN to access the data with recreation of the file on each run. This is particularly helpful in the event of input stream errors resulting in program termination prior to complete execution.

This process is accomplished by executing the following control sequence at the FCCC. (Note: Again, ssssss represents the six-digit station code; yy the year to begin data inclusion in the file; and the second yy the year to end data inclusion. If all available years are requested, use yy = 00 and yy = 99.)

```
        1         2         3         4
12345678901234567890123456789012345678901234567890

@RUN,...

@ASG,A FIREDATALIB*PROGRAMS.

@ASG,A FILE.

@USE 2., FILE.

@ASG,UP NAME.          (NAME MAY BE ANY NAME)

@USE 15., NAME.              (USE SAME NAME AS PREVIOUS LINE)

@XQT FIREDATALIB*PROGRAMS.GETDATA2

  sssssssyy  sssssssyy

  etc., until all stations are listed in ascending order.

@EOF

@FREE 2.

@ASG,T 2.              (THIS ASSIGNS TEMPORARY DISK FILE USED IN PROGRAMS)
```

System software will then respond with a list of the station numbers and the number of card images in each station. The file is now ready for analysis by program RXWTHR or RXBURN, which read weather data from logical unit 15.

Subsequent runs using the same station within the next 6 days would use the following sequence in preparing the data file for program use:

```
         1         2
12345678901234567890

@RUN,...

@ASG,A NAME.                    (NAME IS ONE FROM ORIGINAL RUN)

@USE 15.,NAME.

@ASG,T 2.
```

Using Program RXWTHR

To use RXWTHR, four steps must be followed.

Step 1. Fill out user information sheet(s). (See fig. 9.)

One sheet should be completed for each station to be summarized, or for each summary for a station. The entries on the sheet are mostly self-explanatory, and are briefly summarized here for completeness.

a. Total number of stations in run.--This value is the number of different stations that will have summaries produced in one run of RXWTHR.

b. Fuel model, grass type, and date of last spring frost.--These values need only be entered when NFDRS indices are requested in output tables. NFDRS fuel model descriptions are detailed in appendix A.

c. Slope class.--This value must be entered if NFDRS indices or site adjustment options are selected. Slope classes are defined in appendix B.

d. NFDRS climate class.--This value should be entered on all information sheets and as detailed in appendix C.

e. Activity information.--User comments and documentation are entered here. As many as 80 characters are allowed. Suggested entries include user name, project objectives, site adjustment factors, district, and other information.

f. Duff/soil horizon information.--This information is only required by the selection of duff moisture as an output parameter. Instructions are detailed in appendix D.

g. Summary tables.--If summary tables are desired, select parameters for inclusion.

h. Co-occurrence tables.--If co-occurrence tables are desired, select up to five by filling the blanks with the desired parameters from the total list in the preceding summary section. The only limitation is that wind direction, if selected, must be the first parameter entered in a table composition.

Step 2. Create data file for program use and load program RXWTHR.

File creation was previously covered; program loading is done by the execution of the following control cards:

```
         1         2         3
123456789012345678901234567890

@ASG,A CSSG*RlLIB.

@XQT CSSG*RlLIB.RXWTHR
```

Step 3. Transfer information from user sheet(s) to machine readable formats.

The information from each information sheet constitutes a directive block that tells the program what options are requested and supplies other needed information. There must be one directive block for each station in the analysis and for each multiple run of a single station. Information entered in one directive block does not need repeating in subsequent station analysis nor multiple runs if the information does not change. Details of options and information entry are detailed below with examples.

a. Total number of stations card.--This card must be the first in each directive block. The value is entered in columns 1 and 2, right justified, no decimal.

```
1234567890

nn
```

b. Station, years, and dates of analysis cards.--The first card in this sequence instructs the program that three cards of station, year, and dates information follow. It consists of the word STATION beginning in the first column. The first trailing card contains complete station information as detailed in table 1. This is then followed by two more trailing cards with additional information. The first identifies the years to begin and end data inclusion to the analysis, the second identifies the seasonal dates of data inclusion. If all available years are desired, use 1900 to 1999. Program RXWTHR is restricted to 5 months of data analysis in a single run. For stations with more than 5 months of archival data, see the following section on System Options. For an example, consider Philipsburg Ranger Station for the seasonal dates of June 1 to September 15 for 1960 to 1977.

```
        1         2         3         4         5         6         7
12345678901234567890123456789012345678901234567890123456789012345678901234567890

STATION

PHILIPSBURG RS 243002 5280 46 H 3 P 3 0615     T 3 6200 1

YEARS      1960  1977

DATES      0601  0915
```

c. Activity information card.--The first card in this sequence tells the program that one card of activity information follows. It consists of the word ACTIVITY beginning in column 1. It is followed by a card that contains the information under activity on the user information sheet.

```
        1         2         3         4         5         6         7         8
123456789012345678901234567890123456789012345678901234567890123456789012345678901234567890

ACTIVITY

FIRE WEATHER SUMMARIES FOR PHILIPSBURG, LARRY JONES, PROJECT 5
```

Table 1.--*Station information card*

Input variable	Limits of value ranges	Card columns (inclusive)	Format	Information source
Station name	15 characters	1-15	4A4	user
Station number (6 digits)	0-999999	17-22	I6	user
Station elevation (ft)	0-99999	24-28	F5.0	user
Station latitude (degrees)	0-99	30-31	I2	user
NFDRS fuel model	A-U (except M)	33	A1	appendix A
NFDRS slope class	1-5	35	I1	appendix B
Grass type	A or P	37	A1	appendix A
NFDRS climate class	1-4	39	I1	appendix C
Date of last frost	0101-1231	41-44	I4	user
Repeat run ? (REPEAT)[1]	T or blank	46	L1	user
Save run ? (SAVE)[1]	T or blank	48	L1	user
Site adjustments ? (ADJUST)[1]	T or blank	50	L1	user
Site aspect code	1-4	52	I1	user
Site elevation (ft)	0-99999	54-58	F5.0	user
Site canopy cover	1-2	60	I1	user

If the run is to save computations for the next run to use, enter a T in card column 48, otherwise leave column 48 blank.
If the run is to use computations from the last run, enter a T in card column 46, otherwise leave column 46 blank.
It the run is to make site adjustments, enter a T in card column 50. Be sure if site adjusments are to be made that correct values are entered for aspect, elevation, canopy, and NFDRS slope class.
If the run is not to make site adjustments, leave columns 50 through 60 blank.

[1]Logical variables.

d. Duff/soil information.--This input sequence begins with a card instructing the program as to how many layers (cards) of duff/soil information follow. It consists of the word DUFF in columns 1 through 4, and the total number of layers (2 to 5) in column 12. No decimal is punched. This card is then followed by as many as five cards that define the layer type and thickness (in centimeters). Layer type is in columns 1 through 5 and thickness in columns 6 through 10. Both values have decimals punched.

```
         1         2
12345678901234567890

DUFF       3

1.    3.5

2.    7.0

7.  300.0
```

e. Summary table option cards.--This sequence begins with a card that instructs the program that summary table options follow. The word SUMMARY is printed beginning in column 1 and is followed by as many as 15 cards defining the parameters to be summarized. There is one card for each parameter checked on the sheet. The entire parameter name should be spelled correctly beginning in the sixth column of the card. Information in the parentheses may be excluded. After the last option card has been printed, instruct the program that the last card has been read by placing the word END beginning in the first column of the next card.

```
         1         2         3
12345678901234567890123456789

SUMMARY

     TEMPERATURE

     WIND SPEED
END
```

f. Co-occurrence table option cards.--This sequence begins by instructing the program that co-occurrence option cards follow. This is done by use of the word CO-OCCUR beginning in the first column. It is followed by as many as five option cards that define what tables are to be produced. Values are transferred from the user sheet to cards, one card per table. Make sure the spelling is the same as the parameters in the summary list. The first parameter begins in the sixth column, the second in the 31st, and third (if any) begins in the 56th column. Again, information in the parentheses should be excluded and the last option card is followed by an END card.

```
         1         2         3         4         5         6         7
12345678901234567890123456789012345678901234567890123456789012345678901234567890

CO-OCCUR

     WIND DIRECTION            WIND SPEED

     TEMPERATURE               RELATIVE HUMIDITY       WIND SPEED

END
```

g. The RUN card.--This card must be the last card in each directive block. It consists simply of the word RUN in columns 1 through 3 and signals that all cards in the block have been read. The program then begins execution.

```
         1
1234567890

RUN
```

Step 4. Terminate program execution.

The program will continue execution, reading one directive block at a time, and performing the requested calculations until coming upon an end-of-file mark (@EOF) when reading the first card of the next directive block (Number of Stations). After all directive blocks have been entered, the program is terminated by the following commands;

```
        1
1234567890

@EOF

@FIN
```

Program RXWTHR Error Messages

1. Control sequence incorrect, program aborted.

   Cause: A control card was read that was uninterpretable by the program's internal dictionary. Most common cause of an aborted program is misspelled control words or not starting the word in column 1 of the control card. Can also be caused by not placing an END card at the end of an option series.

2. No summary or co-occurrence option specified, program aborted.

   Cause: There is neither a SUMMARY nor a CO-OCCUR control card in the input stream.

3. Station numbers on descriptor card and data file do not match, program aborted.

   Cause: Keypunch error on STATION card following STATION control card, or error in data file structure. Remember that stations must be analyzed in ascending order.

4. At least one summary option card is incorrect, program aborted.

   Cause: One of the option cards trailing the SUMMARY control card is misspelled or does not begin in column 6.

5. At least one co-occurrence option card is incorrect, program aborted.

   Cause: One of the option cards trailing the CO-OCCUR control card has a misspelled word, or the words do not begin in the correct columns. The correct columns are 6 and 31 for two-way tables, and 6, 31, and 56 for three-way tables.

6. Difference between site and AFFIRMS station greater than 2,000 feet, no adjustments made.

   Cause: When using ADJUST option, elevation differences are limited to 2,000 feet. Program executes, but without any site adjustments.

7. More than 5 months weather summary requested, only first 5 months processed.

   Cause: Self-explanatory--split data into two or three sections.

Program RXWTHR Output Quantity

For each station, the following output is produced:

SUMMARY tables: One (1) page for each parameter requested.

CO-OCCURRENCE tables:

Two-way: One (1) page for each table *per 2 months* analysis; for example, a two-way table from May through August will have a two-page output.

Three-way: One (1) page for each table *for each month's* analysis; for example, a three-way table from May through September will produce five pages of output.

Program RXWTHR Cost Estimates

For a typical RXWTHR run (one station, 5-month analysis, five summary tables, two to three co-occurrence tables) a user can expect costs and resource use as outlined below:

Run priority	Cost	CAU (sec)	Resource time (sec)
DEMAND	$6.00 - $7.00	14 - 15	22 - 25
L	$3.00 - $4.00	14 - 15	22 - 25
M	$2.00 - $3.00	14 - 15	22 - 25
P	$1.00 - $2.00	14 - 15	22 - 25

RXWTHR Demonstration

Putting together steps 1 through 4 results in the execution of a very simple run of RXWTHR. For demonstration purposes, a sample analysis of two stations in a single run will be used. Other runs are demonstrated in the Program Options section. In this example, Philipsburg Ranger Station and West Glacier headquarters are the two stations in the sample. Assume data file is FIREDATALIB*21-24. Remember that stations must be analyzed in ascending order (the same order in which they are retrieved from the data library).

Step 1. Fill out information sheets (see figs. 11 and 12).

Step 2. Create data file for program use and execute program RXWTHR.

```
        1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

@RUN,

@ASG,A FIREDATALIB*PROGRAMS.

@ASG,A FIREDATALIB*21-24.

@USE 2., FIREDATALIB*21-24.

@ASG,UP PHILIP.

@USE 15.,PHILIP.

@XQT FIREDATALIB*PROGRAMS.GETDATA2.

  24020755  24020778

  24300260  24300277

@EOF

@FREE 2.

@ASG,T 2.

@ASG,A CSSG*RlLIB.

@XQT CSSG*RlLIB.RXWTHR
```

Step 3. Transfer information from user sheet(s) to machine readable formats.

Total Number Different Stations in This Run 02

User's Name COLONY, Subunit GLACIER NP, Unit NPS

Project[1] Brief fire weather summaries for West Glacier headquarters

Fire Weather Station Information Station name WEST GLACIER, No. 240207

Elevation 3200 ft., Latitude 46, Climate class[2] 3, Slope class[3]

Fuel model[4], Last frost[5], Grass type[5]: annual ____, perennial ____

Year begin 1955, Year end 1978, Date begin 0601, Date end 0915

Site Adjustment Factors (if any):

Aspect ____ (1=north, 2=east, 3=south, 4=west), Site elevation ____ ft.

Canopy cover ____ (1=open, 2=closed)

Duff/Soil Horizon Information (if Duff Moisture selected. See User's Guide, appendix D):

Layer	Duff/Soil Type	Thickness
1		____ cm
2		____ cm
3		____ cm
4		____ cm
5		____ cm

1/ Use up to 80 characters

2/ See User's Guide, appendix C

3/ See User's Guide, appendix B

4/ For NFDRS indices only. See User's Guide, appendix A

5/ For NFDRS indices only

Summary Table(s) Requested (Select up to 15).

____ State of the weather
__X__ Temperature (degrees F)
____ Relative humidity (%)
__X__ Wind direction (8 point)
____ Wind speed (mi/h)
____ Max temperature (24 h, deg. F)
____ Min temperature (24 h, deg. F)
____ Max relative humidity (24 h, %)
____ Min relative humidity (24 h, %)
____ Precip duration (last 24 h)
____ Precip amount (24 h, 0.01 in)
____ 1 hour fuel moisture (%)
____ 10 hour fuel moisture (%)
____ NFDRS ERC
____ NFDRS BI
____ Duff Moisture (24 h average, %)

Co-occurrence Table(s) Requested (If 2-way table desired leave last space blank. If selected, Wind Direction must always be listed first.):

1	WIND DIRECTION	with	WIND SPEED	with	
2	TEMPERATURE	with	RELATIVE HUMIDITY	with	WIND SPEED
3		with		with	
4		with		with	
5		with		with	

Figure 11.--RXWTHR user information sheet for RXWTHR demonstration using the West Glacier weather station.

Total Number Different Stations in This Run 02

User's Name BRADSHAW, Subunit FIRE LAB, Unit INT EXP STN

Project[1/] Demonstration of RXWTHR output for Philipsburg Ranger Station

Fire Weather Station Information Station name PHILIPSBURG RS, No. 243002

Elevation 5280 ft., Latitude 46, Climate class[2/] 3, Slope class[3/]

Fuel model[4/], Last frost[5/], Grass type[5/]: annual, perennial

Year begin 1960, Year end 1977, Date begin 0501, Date end 0931

Site Adjustment Factors (if any):

Aspect (1=north, 2=east, 3=south, 4=west), Site elevation ft.

Canopy cover (1=open, 2=closed)

Duff/Soil Horizon Information (if Duff Moisture selected. See User's Guide, appendix D):

Layer	Duff/Soil Type	Thickness
1		cm
2		cm
3		cm
4		cm
5		cm

1/ Use up to 80 characters

2/ See User's Guide, appendix C

3/ See User's Guide, appendix B

4/ For NFDRS indices only. See User's Guide, appendix A

5/ For NFDRS indices only

Summary Table(s) Requested (Select up to 15):

- ___ State of the weather
- _X_ Temperature (degrees F)
- ___ Relative humidity (%)
- _X_ Wind direction (8 point)
- ___ Wind speed (mi/h)
- ___ Max temperature (24 h, deg. F)
- ___ Min temperature (24 h, deg. F)
- ___ Max relative humidity (24 h, %)
- ___ Min relative humidity (24 h, %)
- ___ Precip duration (last 24 h)
- ___ Precip amount (24 h, 0.01 in)
- ___ 1 hour fuel moisture (%)
- ___ 10 hour fuel moisture (%)
- ___ NFDRS ERC
- ___ NFDRS BI
- ___ Duff Moisture (24 h average, %)

Co-occurrence Table(s) Requested (If 2-way table desired leave last space blank. If selected, Wind Direction must always be listed first.):

1	WIND DIRECTION	with	WIND SPEED	with	
2	TEMPERATURE	with	RELATIVE HUMIDITY	with	WIND SPEED
3		with		with	
4		with		with	
5		with		with	

Figure 12.--RXWTHR user information sheet for RXWTHR demonstration using Philipsburg weather station.

```
02

STATION

  WEST GLACIER  240207  3200 46 3

YEARS      1955  1978

DATES      0601  0915

ACTIVITY

  BRIEF FIRE WEATHER SUMMARIES FOR WEST GLACIER HEADQUARTERS

         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890

SUMMARY

     TEMPERATURE

     WIND DIRECTION

END
```

```
CO-OCCUR

     WIND DIRECTION                    WIND SPEED

     TEMPERATURE                       RELATIVE HUMIDITY          WIND SPEED

END

RUN

02

STATION

PHILIPSBURG RS 243002  5280  46 3

YEARS    1960  1977

DATES    0501  0931

ACTIVITY

     DEMONSTRATION OF RXWTHR OUTPUT FOR PHILIPSBURG RANGER STATION

RUN
```

Step 4. Terminate program execution.

```
@EOF

@FIN
```

RXWTHR Output Interpretation

Identical output (format) would be produced for each station by the above demonstration. For brevity, only output from the second station, Philipsburg, will be discussed.

SUMMARY TABLES

Relative frequency of occurrence of selected class values, sample size, mean value, standard deviation, median value, and value ranges are tabulated for 10-day and for monthly periods (see fig. 1). For parameters, wind direction and state of the weather, the tables simply consist of relative frequency of occurrence of each singular class and of the most often occurring class. This format is displayed in figure 2.

Interpretation of these tables should be quite straightforward; they are simply summary tables of historical values. In both tables, cumulative frequencies may be computed by the addition of relative frequency values. For example, in May (fig. 1) 85.8 percent (41.1 percent + 16.3 percent + 15.7 percent + 12.7 percent) of the days in the sample had temperatures of less than 70 degrees. Similarly, only 14.2 percent of the temperature readings were 70 degrees or higher.

When obtaining summaries of NFDRS indices the user should consider excluding the first 21 days of a year's record. The reason is that at least that much time is needed for the fuel moisture models to predict "converging" values for the 100- and 1000-hour fuels. (John E. Deeming, personal communication).

CO-OCCURRENCE TABLES--TWO-WAY

In the two-way tables, 2 months of analysis are displayed on each page of output. One page (May and June) is depicted in figure 3. Values within the tables are percent frequency of co-occurrence of selected class values of each parameter. In May, the most frequent co-occurrence condition is a windspeed of 3 to 5 mi/h from the southwest (9.7 percent). Most windspeed values were in the range of 3 to 8 mi/h as seen from the columnar frequency totals. This information should be used for general knowledge of an area's weather and to screen and identify periods that have high probabilities of meeting potential prescription conditions. After a prescription occurrence examination by RXBURN, the information could be used in making new prescriptions that have high probability of occurring.

CO-OCCURRENCE TABLES--THREE-WAY

One month of analysis is tabulated on each page of output for three-way tables. Again, just one page is depicted in figure 4. The last parameter entered (windspeed, in this case) is stratified into five value classes; the first two are stratified into 10 value classes. In this example, the frequency of co-occurrence of a windspeed from 6 to 11 mi/h, a temperature of 59 degrees or less, and a relative humidity of 30 to 49 percent is 9.0 percent. It is obtained by adding the relative frequencies of all those particular stratifications. The number of days in the sample is given in the bottom right portion of the table. This information has the same potential for use as that from the two-way tables, with the added flexibility of a third parameter.

Using Program RXBURN

To use RXBURN, the four steps designated for RXWTHR are required with a slight variation in the substeps. The steps are relisted here with only the changes detailed. The structure of directive blocks is the same as for RXWTHR; they must begin with the Number of Stations card and end with a RUN card.

Step 1. Fill out information sheets for RXBURN (fig. 3).

All values up to prescription factor selections are identical to those in the RXWTHR sheet. A discussion on defining prescriptions for this section is given in appendix E.

Step 2. Create data file and load program RXBURN.

This is done exactly the same as in RXWTHR except the command @XQT CSSG*R1LIB.RXWTHR is altered to read:

```
@XQT CSSG*R1LIB.RXBURN
```

Step 3. Transfer information from user's sheet to machine readable formats.

Items (a) through (d) are exactly the same as in RXWTHR. The changes in this step are outlined and exemplified here. In RXBURN, there is no restriction on the number of months analyzed in one run.

e. User identification cards.--RXBURN allows the information from the second line of the sheet to be entered into the program for documentation. The first card of this sequence instructs the program that the user's name, district, and forest follow on the next card. It consists of the word IDENTIFY beginning in the first column of the card. The information card follows with the user's name in column 1 through 15, the district's name in 21 through 35, and the forest's name in 41 through the 55th column.

```
         1         2         3         4         5         6
123456789012345678901234567890123456789012345678901234567890

IDENTIFY

WILLIAM SHAW          TROUT LAKE RD        CASCADE NF
```

f. Prescription condition cards.--The first card of this sequence instructs the program how many prescription cards follow. The number (nn) may range from 1 to 15; the card consists of the word PRESCRIBE beginning in the first column, and the value nn in columns 11 and 12, right-justified. This card is then followed by the prescription condition cards. These cards are transferred directly from the user information sheet. The parameter name begins in column 6, the preferable RX minimum values are entered in column 33 through 35; preferable RX maximum values in columns 38 through 40; acceptable RX minimum values in columns 43 through 45; and acceptable maximum values in the 48th through 50th column. All values must be right-justified. Values for wind direction should be entered as eight points in a clockwise direction; for example, southwest to northwest, northwest to northeast; and east to west.

```
         1         2         3         4         5
12345678901234567890123456789012345678901234567890

PRESCRIBE 04

     WIND SPEED                    6    7    4   10

     TEMPERATURE                  58   59   55   63

     DAYS SINCE LAST PRECIP        7    7    4    9

     WIND DIRECTION               NW   NW    W    N
```

g. The RUN card.--The RUN card serves the exact purpose of that in RXWTHR and must be the last card in each directive block.

Step 4. Terminate program execution.

The program is terminated the same as RXWTHR was terminated.

In Step 3, the order in which items (b) through (f) are entered is not restricted as long as the order within each item is consistant with the directions stated above. This is also true with input for RXWTHR.

Program RXBURN Error Messages

1. No recognizable input cards - incorrect input stream - program aborted.

   Cause: Misspelled control word on a control card, or control card word not beginning in column 1.

2. At least one option card is incorrect or option word started in the wrong column - program aborted.

   Cause. Misspelled option after the PRESCRIBED control card, or option card not beginning in column 6.

3. Difference between site and AFFIRMS station greater than 2,000 feet, no adjustments made.

   Cause: Self-explanatory.

Program RXBURN Output Quantities

For each station and/or prescription analysis in a single RXBURN run, approximately five pages of output are produced, with a maximum of nine in a full 12-month analysis.

Program RXBURN Cost Estimates

For a typical RXBURN run (one station, 5 to 6 months analysis, three to four prescription parameters), a user can expect the costs and resource use outlined below.

Run priority	Cost	CAU (sec)	Resource time (sec)
DEMAND	$4.00 to $5.00	8 to 9	10 to 11
L	$2.00 to $2.00	8 to 9	10 to 11
N	$1.00 to $1.50	8 to 9	10 to 11
P	$0.75 to $1.00	8 to 9	10 to 11

RXBURN Demonstration

Again, combining steps 1 through 4 results in the execution of a simple run of RXBURN. In this demonstration, one station is used, although more could be analyzed in a manner identical to that shown in RXWTHR. It is again assumed that the data resides on file FIREDATALIB*21-24. Remember, the weather data are read from logical unit 15.

Step 1. Fill out RXBURN information sheet (see fig. 13).

Step 2. Create data file and load program RXBURN.

RXBURN -- USER INFORMATION SHEET

Total Number Different Stations in This Run 01

User's Name BRADSHAW, Subunit FIRE LAB, Unit INT EXP STN

Project[1] Demonstration of RXBURN output for Philipsburg Ranger Station

Fire Weather Station Information: Station name PHILIPSBURG RS, No. 243002

Elevation 5280 ft., Latitude 46, Climate class[2] 3, Slope class[3]

Fuel model[4], Last frost[5], Grass type[5]: annual, perennial

Year begin 1960, Year end 1977, Date begin 0501, Date end 1101

Site Adjustment Factors (if any):

Aspect (1=north, 2=east, 3=south, 4=west), Site elevation ft.

Canopy cover (1=open, 2=closed)

Duff/Soil Horizon Information (if Duff Moisture selected. See User's Guide, Appendix D):

Layer	Duff/Soil Type	Thickness
1		cm
2		cm
3		cm
4		cm
5		cm

1/ Use up to 80 characters

2/ See User's Guide, appendix C

3/ See User's Guide, appendix B

4/ For NFDRS indicies only. See User's Guide, appendix A

5/ For NFDRS indices only

Prescription Factor Selections (Check and set limits for up to 15 factors.):

	Factor	Preferable Rx Minimum	Preferable Rx Maximum	Acceptable Rx Minimum	Acceptable Rx Maximum
	State of the weather				
X	Temperature (deg. F)	65	75	60	80
X	Relative humidity (%)	20	30	20	55
	Wind direction (8 point)				
X	Wind speed (mi/h)	4	9	0	15
	Max temperature (24 h, deg. F)				
	Min temperature (24 h, deg. F)				
	Max relative humidity (24 h, %)				
	Min relative humidity (24 h, %)				
	Days since last precipitation				
	Precip amount (24 h, 0.01 in)				
	1 hour fuel moisture (%)				
	10 hour fuel moisture (%)				
	NFDRS ERC				
	NFDRS BI				
	Duff moisture (24 h average, %)				

Figure 13.--RXBURN User Information Sheet for RXBURN demonstration using Philipsburg weather station.

```
         1         2         3         4              8
12345678901234567890123456789012345678901.............0
@RUN,...
@ASG,A FIREDATALIB*PROGRAMS.
@ASG,A FIREDATALIB*21-24.
@USE 2.,FIREDATALIB*21-24.
@ASG,UP PHILIP.
@USE 15.,PHILIP.
@XQT FIREDATALIB*PROGRAMS.GETDATA2
  24300360  24300277
@EOF
@FREE 2.
@ASG,T 2.
@ASG,A CSSG*RlLIB.
@XQT CSSG*RlLIB.RXBURN
```

Step 3. Transfer information from user's sheet to machine readable formats.

```
01
STATION
PHILIPSBURG RS 243002  5280 46 3
YEARS      1960  1977
DATES      0510  1101
ACTIVITY
   DEMONSTRATION OF RXBURN OUTPUT FOR PHILIPSBURG RANGER STATION
IDENTIFY
LARRY BRADSHAW            FIRE LAB            MONTANA
PRESCRIBE 03
     TEMPERATURE                    65   75   60   80
     RELATIVE HUMIDITY              20   30   20   55
     WIND SPEED                      4    9    0   15
RUN
```

tep 4. Terminate program execution.

```
@EOF
@FIN
```

RXBURN Output Interpretation

Output from this demonstration is displayed in figures 5 through 8.

SUMMARY PAGE

Figure 5 depicts the format and values of the summary page of RXBURN output. Part 1 consists of input information: district name, user name, station information, sample size, and a prescription condition summary. Part 2 is composed of a prescription occurrence summary. It details the mean number of days per season of each prescription type, the frequency of occurrence for each type, and the highest 10-day period and month frequency of each prescription type. In this example, 8 days per year were preferable, 51 were acceptable, and 80 or 58 percent of the season had unacceptable conditions. July had the highest acceptable prescription probability at 45 percent, and the highest 10-day period begins July 1, with a probability of 56 percent. Two 10-day periods, June and October 1-10, had equal probabilities of preferable conditions at 10 percent, while the least likely period for a preferable or acceptable condition to occur is the 10-day period beginning May 1, with a probability of 22 percent of (100 percent - 78 percent).

Figure 6 shows the seasonal progress of prescription occurrences. The sample size, mean number of days, total count of occurrences, and occurrence frequency are given for each prescription type by 10-day, monthly, and seasonal stratifications. This information should be used to follow the historical pattern of prescription occurrences throughout the season. It may be helpful to plot the occurrence frequencies as they change over the season to obtain a better feel for the progression.

Figure 7 is an example of the output from the run length summary analysis of RXBURN. The mean run length (number of days in a row of the same prescription type), and the values at the 25th, 50th (median), and 75th percentile levels are given. Stratification is by 10-day and monthly periods. This information gives an indication of the length of time that favorable or unfavorable conditions tend to persist. In this demonstration, the period July 1 to July 10 averaged a preferable run length of 2 days. At the 25th percentile level, the value was 1 day, 2 days was the median, and the value was 3 days at the 75th percentile level. This means that there is a 50 percent chance of a preferable run lasting at least 2 days and a 25 percent chance of one lasting at least 3 days.

The last section of output from RXBURN is the probability of a prescription type occurring in 1, 2, or 3 days, given an initial prescription type. Stratification is by month. Three months are displayed on each page of output. An example of this output is shown in figure 8. In this example, for a day in May with acceptable conditions, there is a 12 percent chance that tommorow's conditions will also be acceptable, a 9 percent chance that conditions 2 days hence will be acceptable, and a 7 percent chance for acceptable conditions on the third day. If today's conditions, in the example, are unacceptable, there is an 80 percent chance that they will be unacceptable the next day, and only a 2 percent chance of their being acceptable.

System Options

ANALYZING MORE THAN ONE STATION

Up to 99 stations may be analyzed in a single execution of either RXWTHR or RXBURN by building station data files (stations in ascending order) and "stacking" directive blocks (one for each station). This is illustrated in Step 3 of the RXWTHR demonstration. Each directive block must begin with a Number of Stations card and end with a RUN card. Information entered once within a directive block (for example, prescription condition, summary table option, or activity information should not be reentered in following blocks unless the information changes.

STATIONS WITH MORE THAN 5 MONTHS WEATHER DATA

If two or more runs of RXWTHR are required to obtain a full season analysis, set the Number of Stations card value to one (01) and stack two (or three) directives blocks with the dates of analysis cards so that 5 months are analyzed in the first run. The dates of analysis cards in following directive blocks should have different seasonal dates so that the entire season is covered in two or three runs.

MULTIPLE PRESCRIPTION CONDITION ANALYSIS OF ONE STATION

Primary use of this option is to analyze two or more prescription conditions for a single station in one program execution. It may also be used to get more than five co-occurrence tables in RXWTHR.

An initial run of the program stores computed and observed parameter values; subsequent runs have access to stored values, resulting in computer cost and time savings. Values are stored by entering a "T" in column 48 of the first directive block's station information card.

Stored computations are used by the entry of a "T" in column 46 of the second directive block's station information card (leave column 48 blank). The third and following directive blocks do not require' than any of the station information series be entered. There must be one directive block for each prescription occurrence analysis. The following example shows how to analyze four prescription conditions at one station.

```
         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890

01

STATION   (Steps 1 and 2 are assumed to have been completed)

  ANY STATION   123456  2345 45 H B P 3 0615   T

YEARS    1900  1999

DATES    0101  1215

ACTIVITY

    DEMONSTRATION OF MULTIPLE PRESCRIPTION ANALYSIS

IDENTIFY

SANDRA LEE            FERN R.S.            ASPEN N.F.

PRESCRIBE 01

     NFDRS ERC                  2    4      1      10

RUN

01

STATION

  SAME STATION    123456  2345  45 H 3 P 3 0615 T

YEARS    1900  1999

DATES    0101  1215

PRESCRIBE 01

     NFDRS ERC                    4    8    4   15
```

```
RUN

01

PRESCRIBE 01

     WIND SPEED                 13    18    10    20

RUN

01

PRESCRIBE 03

     WIND DIRECTION              S     W     S    NW

     WIND SPEED                  4     8     2    12

     MAX TEMPERATURE            65    72    60    78

RUN

@EOF

@FIN
```

```
         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890
```

There is one restriction in using this option--parameters not computed in the initial run cannot be used in subsequent prescription conditions. This applies only to NFDRS indices, fuel moisture, and duff moisture. Fuel moisture is computed when either fuel moisture or an NFDRS index is specified in a prescription. This also means that fuel models and site adjustments cannot be altered on subsequent runs.

SITE ADJUSTMENTS

Site adjustments factors adjust fuel moisture values (and resulting NFDRS indices) to locations different from those of the base weather station. This option is provided because most weather data is taken at open valley-bottom locations while much prescribed burning is done on higher mountain slopes. The adjustment factors are from research for Fire Behavior Officer training courses offered through the USDA Forest Service. Use is detailed on user information sheets and in table 1. A brief example of a station information card to adjust to a site 800 feet higher than a station, north aspect, closed canopy is shown below. Site elevations must be within 2,000 feet of the base station. It is assumed in this example that steps 1 and 2 have been completed.

```
         1         2         3         4         5         6         7
1234567890123456789012345678901234567890123456789012345678901234567890

 ANY STATION     123456  5000 45 3 3             T 1 5800 2
```

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APPENDIX A - NFDRS FUEL MODELS

Fuel Model A

This fuel model represents western grasslands vegetated by annual grasses and forbs. Brush or trees may be present, but are very sparse, occupying less than one-third of the area. Examples of types where fuel model A should be used are cheatgrass and medusahead. Open pinyon-juniper, sagebrush-grass, and desert shrub associations may be appropriately assigned this fuel model if the woody plants meet the density criteria. The quantity and continuity of the ground fuels vary greatly with rainfall from year to year.

Fuel Model B

Mature, dense fields of brush 6 feet (1.8 m) or more in height are represented by this fuel model. One-fourth or more of the aerial fuel in such stands is dead. Foliage burns readily. Model B fuels are potentially dangerous, fostering intense, fast-spreading fires. This model is for California mixed chaparral, generally 30 years or older. The F model is more appropriate for pure chamise stands. The B model may also be used for the New Jersey pine barrens.

Fuel Model C

Open pine stands typify model C fuels. Perennial grasses and forbs are the primary ground fuel, but there is enough needle litter and branchwood present to contribute significantly to the fuel loading. Some brush and shrubs may be present, but they are of little consequence. Situations covered by fuel model C are open, longleaf, slash, ponderosa, Jeffrey, and sugar pine stands. Some pinyon-juniper stands may qualify.

Fuel Model D

This fuel model is specifically for the palmetto-gallberry understory-pine overstory association of the southeast coastal plains. It can also be used for the so-called "low pocosins" where fuel model O might be too severe. This model should only be used in the southeast because of a high moisture of extinction characteristic.

Fuel Model E

Use this model after leaf fall for hardwood and mixed hardwood-conifer types where the hardwoods dominante. The fuel is primarily hardwood leaf litter. The oak-hickory types are best represented by fuel model E, but E is an acceptable choice for northern hardwoods and mixed forests of the southeast. In high winds, the fire danger may be underrated because rolling and blowing leaves are not accounted for. In the summer, after the trees have leafed out, fuel model E should be replaced by fuel model R.

Fuel Model F

Of the 1972 NFDRS fuel models, only the application of fuel model F has changed. Model F now represents mature closed chamise and oak brush fields of Arizona, Utah, and Colorado. It also applies to young, closed stands and to mature, open stands of California mixed chaparral. Open stands of pinyon-juniper are represented. Fire activity, however, will be overrated at low windspeeds and where ground fuels are sparse.

Fuel Model G

Fuel model G is used for dense conifer stands where there is a heavy accumulation of litter and downed woody material. Such stands are typically overmature and may also be suffering insect, disease, wind, or ice damage--natural events that create a very heavy buildup of dead material on the forest floor. The duff and litter are deep and much of the woody material is more than 3 inches (7.62 cm) in diameter. The undergrowth is variable, but shrubs are usually restricted to openings. Types meant to be represented by fuel model G are hemlock-Sitka spruce, coast Douglas-fir, and windthrown or bug-killed stands of lodgepole pine and spruce.

Fuel Model H

The short-needled conifers (white pines, spruces, larches, and firs) are represented by fuel model H. In contrast to model G fuels, fuel model H describes a healthy stand with sparse undergrowth and a thin layer of ground fuels. Fires in H fuels are typically slow spreading and are dangerous only in scattered areas where the downed woody material is concentrated.

Fuel Model I

Fuel model I was designed for clearcut conifer slash where the total loading of materials less than 6 inches (15.24 cm) in diameter exceeds 25 tons/acre (5.6 kg/m^2). After settling and the fines (needles and twigs) fall from the branches, fuel model I will overrate the fire potential. For lighter loadings of clearcut conifer slash, use fuel model J, and for light thinnings and partial cuts where the slash is scattered under a residual overstory, use fuel model K.

Fuel Model J

This model complements fuel model I. It is for clearcuts and heavily thinned conifer stands where the total loading of materials less than 6 inches (15.24 cm) in diameter is less than 25 tons/acre (5.6 kg/m^2). Again, as the slash ages, the fire potential will be overrated.

Fuel Model K

Slash fuels from light thinnings and partial cuts in conifer stands are represented by fuel model K. Typically the slash is scattered about under an open overstory. This model applies to hardwood slash and to southern pine clearcuts where the loading of all fuel is less than 15 tons/acre (3.36 kg/m^2).

Fuel Model L

This fuel model is meant to represent western grasslands vegetated by perennial grasses. The principal species are coarser and the loadings heavier than those in model A fuels. Otherwise, the situations are very similar; shrubs and trees occupy less than one-third of the area. The quantity of fuel in these areas is more stable from year to year. In sagebrush areas, fuel model T may be more appropriate.

Fuel Model N

This model was constructed specifically for the sawgrass prairies of south Florida. It may be useful in other marsh situations where the fuel is coarse and reedlike. This model assumes that one-third of the aerial portion of the plants is dead. Fast-spreading, intense fires can occur even over standing water.

Fuel Model O

The O model applies to dense, brushlike fuels of the southeast. O fuels, except for a deep litter layer, are almost entirely living in contrast to B fuels. The foliage burns readily except during the active growing season. The plants are typically over 6 feet (1.8 m) tall and are often found under an open stand of pine. The high pocosins of the Virginia and the North and South Carolina coasts are the ideal of fuel model O. If the plants do not meet the 6-foot (1.8-m) criteria in those areas, fuel model D should be used.

Fuel Model P

Closed, thrifty stands of long-needled southern pines are characteristic of P fuels. A 2- to 4-inch (5- to 10-cm) layer of lightly compacted needle litter is the primary fuel. Some small diameter branchwood is present, but the density of the canopy precludes more than a scattering of shrubs and grass. Fuel model P has the high moisture of extinction characteristic of the southeast. The corresponding model for other long-needled pines is U.

Fuel Model Q

Upland Alaskan black spruce is represented by fuel model Q. The stands are dense, but have frequent openings filled with usually inflammable shrub species. The forest floor is a deep layer of moss and lichens, but there is someneedle litter and small-diameter branchwood. The branches are persistent on the trees, and ground fires easily climb to the tree crowns. This fuel model may be useful for jack pine stands in the Lake States. Ground fires are typically slow spreading, but a dangerous crowning potential exists. Users should be alert to such events and note those levels of spread component and burning index when crowning occurs.

Fuel Model R

This fuel model represents the hardwood areas after the canopies leaf out in the spring. It is provided as the off-season substitute for E. It should be used during the summer in all hardwood and mixed conifer-hardwood stands where more than half of the overstory is deciduous.

Fuel Model S

Alaskan or alpine tundra on relatively well-drained sites is the S fuel. Grass and low shrubs are often present, but the principal fuel is a deep layer of lichens and moss. Fires in these fuels are not fast spreading or intense, but they are difficult to extinguish.

Fuel Model T

The bothersome sagebrush-grass types of the Great Basin and the Intermountain West are characteristic of T fuels. The shrubs burn easily and are not dense enough to shade out grass and other herbaceous plants. The shrubs must occupy at least one-third of the site or the A or L fuel models should be used. Fuel model T might be used for immature scrub oak and desert shrub associations in the West, and the scrub oak-wire grass type in the Southeast.

Fuel Model U

Closed stands of western long-needled pines are covered by this model. The ground fuels are primarily litter and small branchwood. Grass and shrubs are precluded by the dense canopy, but occur in the occasional natural opening. Fuel model U should be used for ponderosa, Jeffrey, sugar, and red pine stands of the Lake States. Fuel model P is the corresponding model for southern pine plantations.

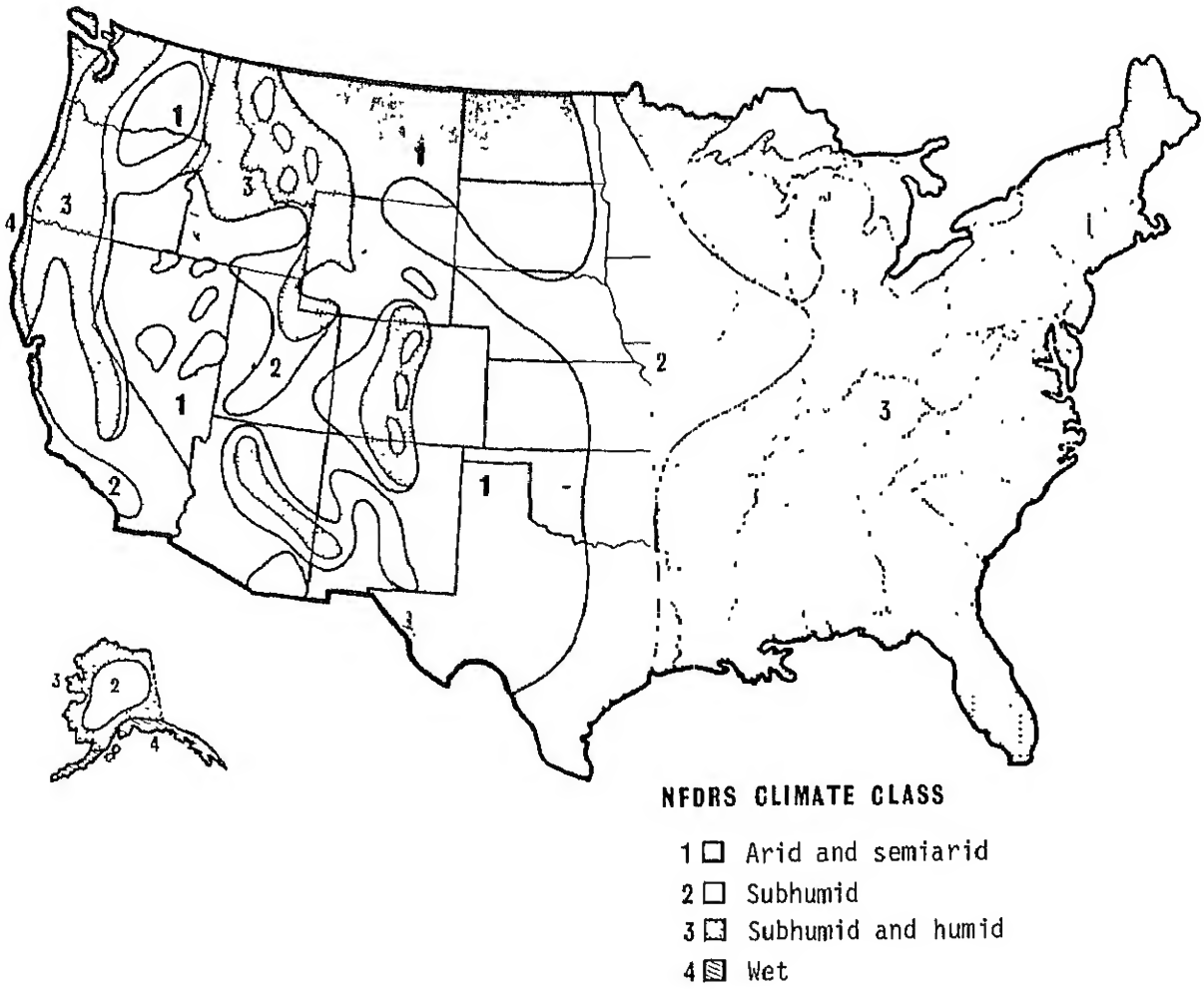
APPENDIX B - NFDRS SLOPE CLASS DEFINITIONS

Slope class	Slope (percent)
1	0-25
2	26-40
3	41-55
4	56-75
5	75 and above

APPENDIX C - NFDRS CLIMATE CLASS DEFINITIONS

NFDRS climate class	Thornthwaite[1] humidity province	Characteristic vegetation	Regions
1	Arid	Desert (sparse grass and scattered shrubs)	Sonoran deserts of west Texas, New Mexico, southwest Nevada, and western Utah; and the Mojave Desert of California.
2	Semiarid	Steppe (short grass and shrubs)	The short grass prairies of the Great Plains; the sagebrush steppes and pinyon/juniper woodlands of Wyoming, Montana, Idaho, Colorado, Utah, Arizona, Washington, and Oregon; and the grass steppes of the central valley of California.
3	Subhumid (rainfall deficient in summer)	Savanna (grasslands, dense brush and open conifer forests)	The Alaskan interior, the chaparral of Colorado, Arizona, New Mexico, the Sierra Nevada foothills, and southern California; ponderosa pine woodlands of the West; and mountain valleys (or parks) of the northern and central Rockies.
	Subhumid (rainfall adequate in all seasons)	Savanna (grasslands and open hardwood forests)	Bluestem prairies and bluestem-oak-hickory savanna of Iowa, Missouri, and Illinois.
	Humid	Forests	Almost the entire eastern United States; and those higher elevations in the West that support dense forests.
4	Wet	Rain forest (redwoods, and spruce-cedar-hemlock)	Coast of northern California, Oregon, Washington, and southeast Alaska.

[1]Thornthwaite 1931.



Appendix C Map.--NFDRS climate class (Deeming and others 1977).

APPENDIX D - DUFF/SOIL HORIZON STRUCTURE

Programs RXWTHR and RXBURN offer a newly applied duff moisture model. It must be stressed that the model is theoretical and has not been validated by field tests. It is based upon theoretical properties of water vapor transport through porous mediums. The model was developed by Michael Fosberg (Fosberg 1975) and adapted for computer usage on archival fire weather data by a consulting firm. *It is offered strictly on an experimental basis in the present versions of RXWTHR and RXBURN.* Further work and field testing are planned and resulting changes and calibrations will be incorporated into updated versions of the programs.

To employ this option of programs RXWTHR and RXBURN, the user needs to provide information about the structure of forest floor. The floor must be broken into layers of homogeneous materials: duff, humus, and a boundary or stable layer. At the surface, the boundary layer is the air, at the bottom, the layer is considered to be a sand. The user must specify the type of material of each layer and the thickness of each layer. The types of materials that the model will presently accept and the appropriate codes to be entered in the duff information cards are as follows:

Duff/soil type	Code
Lodgepole pine duff	1
Lodgepole pine humus	2
Ponderosa pine duff	3
Ponderosa pine humus	4
Douglas-fir duff	5
Douglas-fir humus	6
Sand	7

The thickness of each layer is to entered by the user in centimeters. At this time the bottom boundary layer is assumed to be sand with a thickness from 100 to 300 cm (approximately 40 to 120 inches). This information still must be entered. The type entered for each layer is then used to calculate layer timelags based on physical properties of each of the layers.

APPENDIX E - DEFINING PRESCRIPTION CONDITIONS

RXBURN offers the unique feature of allowing two value ranges to be entered for each prescription factor in a prescription. They are defined as "preferable" and "acceptable" burning conditions. Preferable conditions are those ideal for meeting burning objectives. Acceptable conditions are broader (and more often occurring) ranges of values that will still meet burning objectives, though not as surely as burning in preferable conditions. All values outside the range of acceptable conditions are considered unacceptable.

As an example, a manager might plan to burn with a prescription that included a temperature of 58° or 59° F., last precipitation 7 days ago, and wind out of the northwest at 6 or 7 miles per hour. Realizing this tight prescription may have a limited chance of occurring, they consult climatological summaries from RXWTHR and decide on an acceptable prescription that will probably still meet burning objectives, and yet have a reasonable probability of occurring. The acceptable prescription might than include a temperature of 55° to 63° F., last precipitation 4 to 9 days ago, and a windspeed of 4 to 10 miles per hour from the west to north. In terms of input to RXBURN, this prescription would look like this.

	Preferrable RX		Acceptable RX	
Factor	Minimum	Maximum	Minimum	Maximum
Temperature, °F.	58	59	55	63
Days since last precipitation	7	7	4	9
Wind speed (mi/h)	6	7	4	10
Wind direction	NW	NW	W	N

Any values outside the acceptable ranges would constitute an unacceptable burning condition. Note that wind direction limits must be entered in a clockwise manner.

A word of caution. Windspeed and direction can be quite unreliable except for the site at which they were collected. Consequently, the manager must rely to a large extent on experience and knowledge of the effects of local topography on wind in order to interpret RXBURN values for these parameters.

APPENDIX F - RXWTHR AND RXBURN PROGRAM DOCUMENTATION

This appendix contains documentation of all routines and functions of programs RXWTHR and RXBURN. It is intended to serve as a reference for programers and users interested in the logic and structure of the programs. It provides variable identification of values stored in COMMON BLOCKS.

A general overview of the structure of RXWTHR precedes its documentation. This is followed by a general overview of program RXBURN and documentation of the details of RXBURN that differ from those in RXWTHR.

General Overview of RXWTHR

Program RXWTHR computes summary tables and co-occurrence tables of user-selected fire weather parameters. All user input is read from logical unit 5 in subroutine SETUP. All weather data from the National Fire Weather Data Library is read in subroutine CMPUTE from logical unit 15. Based on user options, the program will calculate either summary tables or co-occurrence tables, or both. In each run of RXWTHR, a maximum of 15 summary tables and five co-occurrence tables can be computed.

The general flow of the program is as follows:

Step 1: Read number of stations to be analyzed in mainline control program RXWTHR.

Step 2: RXWTHR calls SETUP, which reads user control sequence. SETUP then calls INTERP to interpret user input and set program control variables and computation levels. INTERP then returns to SETUP, which then calculates adjustment codes if needed and returns to RXWTHR.

Step 3: RXWTHR then calls CMPUTE. CMPUTE sets initial values and begins reading weather data and computing needed values as per user specification and summarizes data by calling SUM.

Step 4: After all data have been read and values accumulated in SUM, CMPUTE calculates final statistics and outputs tables through two subroutines. RITE1 outputs the summary tables, RITE2 outputs the co-occurrence tables.

Step 5: After first station has been analyzed and queued to output, CMPUTE returns to RXWTHR to check for another station to analyze. If there are none the program terminates normally. If there is another station, general flow starts at Step 2 again until all stations have been analyzed.

In the following pages, the COMMON BLOCKS used by RXWTHR are first defined. Mainline program RXWTHR is then documented. All other routines and functions are then documented in alphabetical order.

RXWTHR Common Blocks

Program RXWTHR uses nine labeled COMMON BLOCKS and no unlabeled COMMON BLOCKS. These are defined as follows:

COMMON /FIRE/ : Contains parameters used in system fire model routine.

VALUES SET : Values in /FIRE/ are set in subroutine FUELS and subroutine CURING, all variables are REAL.

ARIABLE	:	DESCRIPTION
D	:	Weight of dead and down 1-hour fuels (pounds per square foot)
0D	:	Weight of dead and down 10-hour fuels (pounds per square foot)
00D	:	Weight of dead and down 100-hour fuels (pounds per square foot)
000D	:	Weight of dead and down 1,000-hour fuels (pounds per square foot)
DP	:	Weight of dead and down 1-hour fuels + cured green fuels
	:	Indicates first call to subroutine ERCSC
PTH	:	Depth of fuel bed (inches)
	:	Height of dead fuels (inches)
	:	Height of live fuels (inches)
WOOD	:	Moisture content of woody fuels (percent)
ERB	:	Moisture content of herbs (percent)
GHERB	:	Surface area to volume ratio herbaceous fuels
WOOD	:	Surface area to volume ratio woody fuels
100D	:	Surface area to volume ratio 100-hour dead and down
31D	:	Surface area to volume ratio 1-hour dead and down
310D	:	Surface area to volume ratio 10-hour dead and down
000D	:	Surface area to volume ratio 1,000-hour dead and down
ERB	:	Weight of herbaceous material
ERBC	:	Weight of cured herbacious material
)FC	:	Wind factor
)OD	:	Weight of woody fuels
)	:	Moisture of extinction of dead and down fuels (percent)
ERBC	:	Moisture content of cured herbaceous material (percent)

MON /LABELS/	:	Contains alphanumeric labels for output. All variables are integer and set in BLOCK DATA.

AY	:	DESCRIPTION
.1(4,17)	:	Header labels for all parameters
.2(9)	:	Header labels for wind direction
.3(10)	:	Table labels for summary tables
.4(17)	:	Units labels for all parameters
L5(17)	:	Short header labels for co-occurrence tables
NTH(12)	:	Month labels (JAN--DEC)

MMON /LIM/	:	Contains class level limits for all parameters. All values in /LIM/ are integer and are set in BLOCK DATA except for LOW, which is set in the output routines.

RAY	:	DESCRIPTION
MIT(9,17)	:	Contains class value limits for all parameters except STATE OF THE WEATHER
MSW(10)	:	Contains class value limits for STATE OF THE WEATHER
)W(9)	:	Contains lower class limits for output tables

)MMON /OBSERV/	:	Contains values from weather observation, computed moisture values, and other values needed for computation

RRAYS	:	DESCRIPTION
)B(22)	:	Contains weather observation, plus computed values
OB(1)	:	Station number
OB(2)	:	Year
OB(3)	:	Month
OB(4)	:	Day
OB(5)	:	State of the weather
OB(6)	:	Temperature

IOB(7) : Relative humidity

IOB(8) : Duff moisture (computed)

IOB(9) : Wind direction

IOB(10) : Windspeed

IOB(11) : Stick moisture (observed)

IOB(12) : Maximum temperature

IOB(13) : Minimum temperature

IOB(14) : Maximum relative humidity

IOB(15) : Minimum relative humidity

IOB(16) : Precipitation duration

IOB(17) : Precipitation amount

IOB(18) : Moisture index (1, 2, or 3)

IOB(19) : 1-hour fuel moisture (computed)

IOB(20) : 10-hour fuel moisture (computed or observed)

IOB(21) : 1978 NFDRS ERC (computed)

IOB(22) : 1978 NFDRS BI (computed)

STRUC(5,9) : Contains duff/soil horizon structure information as input from SETUP. There are up to five horizons.

STRUC(I,1) : Soil or duff type code

STRUC(I,2) : Thickness of layer (centimeters)

STRUC(I,3) : Particle temperature timelag (seconds)

STRUC(I,4) : Particle moisture timelag (seconds)

STRUC(I,5) : Bulk density layer (grams per cubic centimeter)

STRUC(I,6) : Particle density (grams per cubic centimeter)

STRUC(I,7) : Hydraulic conductivity (centimeters per second)

STRUC(I,8) : Moisture coefficient (dimensionless)

STRUC(I,9) : Temperature coefficient (dimensionless)

IELV : Adjustment elevation code (1--3)

IDUFF : Duff moisture option specification (0 = no, 1 = yes)

IDAYB	:	Day to begin sample inclusion
IDAYE	:	Day to end sample inclusion
ISLO	:	Adjustment slope code (1 or 2)
IYEARB	:	Year to begin sample
IYEARE	:	Year to end sample
ELEV	:	Station elevation
LAT	:	Station latitude (I2)
MONTHB	:	Month to begin sample
MONTHE	:	Month to end sample
REPEAT	:	Logical (L1) variable that specifies if run is to read from disk file created by SAVE option
SAVE	:	Logical (L1) variable that specifies if disk file is to be created for subsequent REPEAT runs
NUMSTA	:	6-digit station identifier code
MXT	:	Maximum temperature - ALPHA format
MNT	:	Minimum temperature - ALPHA format
MXRH	:	Maximum relative humidity - ALPHA format
MNRH	:	Minimum relative humidity - ALPHA format
IAPT	:	Precipitation amount - ALPHA format

COMMON /STATS/	:	Contains statistical summary values for summary and co-occurrence tables. Arrays for use in summary tables are stratified by month (5); 10-day period of month (3); and summary table number (15). Arrays for co-occurrence are stratified by table number (5); month (5); first order class number (10); second order class number (10); and third order class number (5) transferred into a vector.

ARRAY		DESCRIPTION
MEAN(5,3,15)	:	Accumulates values stratified as described above for summary tables.
SD(5,3,15)	:	Accumulates sums of squares and then computed values of standard deviations are entered, stratified as described above.
IXTREM(5,3,15)	:	Holds maximum values of parameters for use in range display in summary tables.
IXYEAR(5,3,15)	:	Holds minimum values of parameters for use in range display in summary tables.

MEDIAN(2250) : Holds values ordered by class for computation of median values for display of summary tables. Values are stratified by period of month (3), month (5), summary table number (15), and class interval number (12), tranformed into a vector.

CUMCO(12500) : Cumulator array for co-occurrence tables, stratified as described above.

COUNT(5,3) : Holds sample size stratified by month and period of month.

Program RXWTHR

Narrative: Program RXWTHR is the mainline control program for the computation of climatological summary co-occurrence tables. It keeps track of the number of stations to be analyzed and the number that have been analyzed. It resets the program or terminates it according to the number of stations requested.

The logic is:

Step 1: Set run number to zero.

Step 2: Read number of stations to be analyzed.

Step 3: If at EOF, terminate run normally; if not, continue to Step 4.

Step 4: Call SETUP

Step 5: Call CMPUTE

Step 6: Rewind disk file created by SAVE option (if used) and add 1 to the run number.

Step 7: Check to see if last station has been analyzed. If not, return to Step 2. If so, rewind weather data file, set run number to zero again, and return to Step 2 to see if stations are to be reanalyzed with perhaps different fuel models, slope classes, or co-occurrence tables.

COMMON BLOCKS USED: NONE

A listing of all SUBROUTINES and FUNCTIONS that compose the body of RXWTHR now follows. They are listed in alphabetical order and follow the same format as the mainline program documentation of RXWTHR.

RXWTHR Fuctions and Subroutines

SUBROUTINE ADSORP(I)

Narrative: Subroutine ADSORP is used in duff moisture calculations during periods that experienced rainfall. ADSORP is called by PERCOL, which was called by DUFF, which was called by CMPUTE. The parameter I is passed into ADSORP and is the current layer in the duff horizon that is being simulated.

COMMON BLOCKS used: /BLOCK2/, /OBSERV/

The logic is:

Step 1: Solve for effective percolation rate PPP, and then set QQQ and RRR from it.

Step 2: Call ROOT--ROOT returns value for THETA after solving a third degree polynomial equation.

Step 3: Compute particle moisture content adsorption rate (percent moisture content per second).

Step 4: Compute actual moisture content change (amount = rate x time).

Step 5: Adjust THETA (volumetric content of voids) by amount adsorbed by particles.

Step 6: Calculate effective hydraulic conductivity due to water adsorption.

Step 7: Return to PERCOL.

SUBROUTINE ALPHA(RF,AF)

Narrative: Subroutine ALPHA is passed the array RF, an array containing real values. It ENCODES the values and if the value is zero, sets it equal to an alpha blank in an A4 format. This makes all output of relative frequency values alpha, for easier readability. AF is the array that is passed back for output. ALPHA is called by RITE1 and uses no COMMON BLOCKS.

BLOCK DATA

Narrative: Routine BLOCK DATA sets data constants for all LABELED COMMON BLOCKS that are given values through the use of DATA statements.

COMMON BLOCKS USED: /OPSET/, /LABELS/, /LIM/

FUNCTION CALV(F)

Narrative: This real function converts temperature in degrees F to temperature in degrees Kelvin and returns to calling program. CALV is a function from the NFDRS.

SUBROUTINE CMPUTE

Narrative: This routine is the major computation section of the program. It reads the weather data and calls all other subroutines in the process. It computes statistical summaries and directs output procedures by calling output routines at appropriate places in the flow.

COMMON BLOCKS USED: /SET/, /OBSERV/, /STATS/, /OPSET/, /LABELS/, /FIRE/, /LIM/

The logic is:

Step 1: Initialize all constants, including site adjustment factors (IADJUS), zero out all values in COMMON BLOCK /STATS/.

Step 2: If fuel model is needed as per computation level (L), match the fuel model that was requested (MOD) with the test array of (MOD1) and get fuel bed parameters by calling FUEL(II). Then set the day of last frost (LFROST) to a month and day value for use in subroutine CURING.

Step 3: Compute fire weather station pressure, adding 200 feet to the station elevation if Alaskan.

Step 4: Begin DO LOOP of reading weather data from logical unit 15.

Step 5: If REPEAT is run, skip calculations and read values from disk file. Otherwise, make checks for correct station and to see if the day just read is within the time period requested. If maximum/minimum values are requested for analysis, but missing from data record, read another record (Step 4).

Step 6: Determine if a new season has started. A new season is said to have started if the year changes or there is a 30-day break in the records. If new season has started, set the logical variable INIT to .TRUE. This allows for initial values to be set.

Step 7: Call processing option setting routine OPTFIX.

Step 8: Call data testing routine TESTWX. If there is an error in the data, write a message and read the next record.

Step 9: If DUFF MOISTURE is requested, CALL DUFF(INIT,IFIRST)

Step 10: If no fuel moistures or NFDRS indices are requested, go to Step 20.

Step 11: Compute solar declination by calling function DECL and passing month and day.

Step 12: Get 1- and 10-hour fuel moistures from subroutine ONETEN.

Step 13: Make site adjustments if requested and add to values of 1- and 10-hour fuel moistures.

Step 14: If no NFDRS indices are requested go to Step 19.

Step 15: Compute 100- and 1,000-hour fuel moistures by use of routines M100 or M100A, depending on value returned from OPTFIX.

Step 16: Call subroutine CURING to determine state of green vegetation.

Step 17: Call subroutine ERCSC to determine the day's NFDRS indices.

Step 18: Assign computed values of ERC and BI to elements 21 and 22 of IOB, respectively.

Step 19: Assign correct values of 1- and 10-hour fuel moisture to elements 19 and 20 of IOB, respectively.

Step 20: If computations are to be saved for next run use, write them to the disk file that is called 'tape 2'.

Step 21: Call subroutine SUM. This routine does the intermediate statistical summaries.

Step 22: Read a new record (Step 4).

At this point all records for the station have been read and summed in subroutine SUM and are ready for final computations and output.

Step 30: If no summary tables have been requested, skip to co-occurrence table output section. Otherwise, proceed.

Step 31: Begin DO LOOP for each summary table requested (1 to NMEANS).

Step 32: Get summary parameter type, order, and write out header by call to RITE1. If fuel model was used, write out fuel model letter and slope class. Then write out table-tops.

Step 33: Begin DO LOOP for each month of data (1 to NMONTH).

Step 34: Begin DO LOOP for each period of the month (1 to 3).

Step 35: Set cumulative frequencies, relative frequencies, extreme values, and if cumulative frequency has reached 50% get median value (MED) by calling subroutine MIDPT2 (this is for first class interval).

Step 36: Begin DO LOOP for each class interval beginnin at 2. (Number 1 was set in Step 35).

Step 37: Set cumulative frequencies, etc., as in 35 till median value is determined. Then end Step 36 LOOP.

Step 38: Compute period mean, standard deviation, and output period mean, standard deviation, median, range values, and relative frequency distribution by calling RITE1.

Step 39: Continue LOOP from Step 34.

Step 40: Continue LOOP from Step 33.

Step 41: Repeat process, this time by monthly stratifications by summing three periods for each month, and outputting by call to RITE1.

Step 42: Repeat entire process for each summary table requested (Step 31)

At this point all summary tables have been computed and written to the print queue. Flow continues in computation and output of co-occurrence tables.

Step 50: If no co-occurrence tables were requested, return to RXWTHR.

Step 51: Begin DO LOOP for number of co-occurrence tables requested.

Step 52: Set control points based upon options and order of options.

Step 53: If this table is a 2-way table, skip to Step 70. Otherwise, proceed.

Step 54: Begin DO LOOP for number of months

Step 55: Sum total number of days in all periods of the month and write out header, fuel model, and slope class if needed.

Step 56: Zero out row and column totals and begin computation loops.

Step 57: First write out table-tops by calling subroutine RITE2.

Step 58: Begin DO LOOP for number of rows (class intervals) for first parameter in the table (1 to L4 [Option I,1]).

Step 59: Compute an entire row of percent frequency of co-occurrence for the class values and output the entire row by calling RITE2.

Step 60: Continue Step 58 LOOP.

Step 61: Write out column frequency totals by calling RITE2 (there are two sets).

Step 62: Compute total frequency (row and column totals should be 100%) and write totals out along with the total count for the month (number of days in the sample).

Step 63: Repeat for each month in data set (Step 54).

Step 64: Repeat for each table (Step 51).

The next block is for computation and output of 2-way tables of co-occurrence.

Step 70: Begin DO LOOP for number of months.

Step 71: Write headers, fuel model, and slope class if needed.

Step 72: Zero out row and column arrays (ROWTOT and COLTOT).

Step 73: Write out table-tops.

Step 74: Compute simple 2-way co-occurrence frequencies and output results one row at a time.

Step 75: Compute row and column total, sample size, and write it out.

Step 76: Repeat for each month (Step 70).

Step 77: Repeat for each table (Step 51).

At this point all summary and co-occurrence tables have been computed and queued to the printer.

Step 80: If computations were saved on disk, put end of file mark (EOF) at the end of the data.

Step 81: Return to RXWTHR.

SUBROUTINE CURING(INIT)

Narrative: Subroutine CURING is designed to model the progression of green vegetation through the growing season from dead, through greenup, through transition, and again to the dead or cured state. The subroutine was developed by the NFDRS work unit, and taken in entirety from the NFDRS. Full documentation of this subroutine is available through appropriate NFDRS publications.

COMMON BLOCKS USED: /OBSERV/, /FIRE/

FUNCTION DECL(MONTH,IDAY)

Narrative: This function computes the solar declination angle and is taken from NFDRS research. It is used for calculations of 100-hour fuel moisture.

FUNCTION DLIGHT(LAT,DECL)

Narrative: This function computes the total hours of daylight for the station latitude and the solar declination angle as computed in DECL. It is also used in calculations of 100-hour fuel moisture. DLIGHT was derived from NFDRS algorithms.

SUBROUTINE DUFF(INIT,IFIRST)

Narrative: This subroutine controls the calculation of duff moisture. It is still in the developmental stages and should be used with caution. "The model was developed from numerical and analytical solutions of the diffusion forms of the mass continuity equation and the first law of

thermodynamics. Analytical solutions provided a fundamental framework to evaluate nonlinear interactions obtained in the numerical solutions. Dimensional analysis was used to define the relationship between the soil properties used in the model." (Fosberg 1975.)

COMMON BLOCKS USED: /OBSERV/, /BLOCK1/, /BLOCK2/

The logic is:

Step 1: Set subroutine constants.

Step 2: If it is the first time the subroutine has been called on this run, set up physical characteristics of the duff horizon. These factors include (by layer):

1. Packing ratio (BETA)
2. Porosity (PHI)
3. Vapor Diffusivity (NU)
4. Thermal Diffusivity (KAPPA)
5. Layer Moisture Timelag (TAURHO)
6. Layer Temperature Timelag (TAUTMP)
7. Modified Exponential Exchange Functions (temperature [CHITMP])
8. Modified Exponential Exchange Functions (vapor [CHIRHO])
9. Depth of layer (DEPTH).

Step 3: If it is initial season, call PROFL1 to set up initial temperature and relative humidity profiles of the horizons.

Step 4: Begin simulation.

Step 5: Get input values of temperature and relative humidity.

Step 6: Begin 24-hour duff moisture simulation (2-hour increments).

Step 7: Use harmonic analysis to model temperature and relative humidity cycles for each time increment.

Step 8: If TPTAMT is greater than zero, and simulation time is less than precipitation duration, it is still raining. GO TO Step 10.

Step 9: This means that it has either stopped raining or did not rain. If EMC is less than FIBSAT, regular solution will be used and SWITCH is .TRUE. for the layer. Otherwise, moisture is lost at the above saturation point rate as defined by DTHETA. This is done for each layer, and skips to Step 11.

Step 10: Call PERCOL. This sets a percolation rate of free water through the horizons which is adsorped to an extent by a value of DTHETA, and contributes to the overall moisture content of the horizon by a volumetric amount that is determined by solution of a third degree polynomial equation by subroutine ROOT. This value is determined for each layer, and what is adsorped by one layer is not available for adsorption by the next.

Step 11: Determine vapor pressure for each layer and set top layer boundary conditions and intermediate layers to last value of layer above.

Step 12: Modify layer temp and density by exchange functions.

Step 13: Recalculate vapor pressure using new layer temperature (sat v.p.).

Step 14: Compute current saturation density.

Step 15: If EMC greater than FIBSAT, current density = saturation density.

Step 16: Compute vapor pressure and layer relative humidity from equation of state.

Step 17: If SWITCH of layer is .TRUE. get particle moisture by calling DUFFMC which calculates EQMC of particles based on temperature and relative humidity. Compute average, simulate next time period, until 24 hours have been simulated, then return to CMPUTE with IOB(8) = duff moisture.

SUBROUTINE DUFFMC(TEMP,HUMID,EQM,TYPE)

Narrative: Subroutine DUFFMC computes duff particle equilibrium moisture contents based on a regression shown in the Wood Products Handbook, using predictors of temperature and relative humidity. It also computes EQMC's for soil or loam boundary layers.

FUNCTION EQMC(TEMP,RH)

Narrative: This function provides the same information as DUFFMC, but is in the form of a function that does not have the capability for soil and boundary layer computations.

SUROUTINE ERCSC(ERC,BI)

Narrative: This computational routine determines potential fire behavior from the NFDRS fuel model and the current fire weather. It then computes the fire danger indices based on the potential fire behavior. The model is based on work of Rothermel (1972) and Albini (1976) and modified by Deeming and others (1977). This routine is taken directly from the NFDRS system and again is fully documented there.

COMMON BLOCKS USED: /FIRE/

SUBROUTINE ERROR(I)

Narrative: This subroutine is called by several routines in the system and is passed the value I. The routine is called when an error is detected. An error message is printed by means of a computed GO TO statement and processing continues or the program is aborted, depending on the severity of the error.

FUNCTION FREEZE (ITMN,NUMDAY)

Narrative: This function determines if a killing frost has occurred and is called by CURING. A killing frost is considered to have occurred if the minimum temperature has been less than 33 degrees for a total of 5 days, or if a minimum temperature of 25 degrees or less occurs. This logical function is taken from the NFDRS.

SUBROUTINE FUEL(II)

Narrative: This routine sets the parameters of the fuel bed for analysis or modeling by ERCSC. The routine contains the 20 NFDRS stylized fuel models, and assigns the correct values to the variables in COMMON BLOCK /FIRE/. FUEL is called by CMPUTE.

IBROUTINE INTERP(MVALUE,MOPTIN)

Narrative: This routine interprets what was read in SETUP, sets program directives, and omputation levels (L). It is passed the alphanumeric words that were read by SETUP, matches hem with its own word dictionary, and sets option parameters and computation levels. If no atch is found, ERROR is called with the appropraite value passed.

OMMON BLOCKS USED: /SET/, /OPSET/

FUNCTION IOUT(KSET)

Narrative: This function examines the option number and sets a value (IOUT) for use in COMPUTED GO TO in the output routines.

FUNCTION IRND(X)

Narrative: This integer function rounds a real number then performs a FORTRAN standard IFIX operation on it.

INTEGER FUNCTION ISUB1(I,J,K,L)

Narrative: This function converts a four-way stratification into a vector for computer storage on a computer that is restricted to three dimensional arrays. This particular function is used in computing median values in the summary array MEDIAN.

INTEGER FUNCTION ISUB2(I,J,K,L,M)

Narrative: This function converts a five-way stratification into a vector for computer storage. This particular function is used in co-occurrence stratification of array CUMCO.

INTEGER FUNCTION JET(I)

Narrative: This function groups precipitation and ERC values into categories of graduated value.

SUBROUTINE M100(DECL,LAT,BNDRY)

Narrative: The routine is called by CMPUTE to calculate 100-hour fuel moistures. It is the preferred method of 100-hour calculations. Maximum and minimum temperatures and relative humidities are used to calculate extreme values of equilibrium moisture contents which are then integrated with DLIGHT resulting in a weighted average value that is used in the 100-hour computations. This routine was developed by the NFDRS work unit and includes BNDRY values.

COMMON BLOCKS USED: /OBSERV/

SUBROUTINE M100A(IWTFLG,LAT,DECL,BNDRY)

Narrative: This routine developed by the NFDRS work unit is for computing values of 100-hour fuel moisture when maximum and minimum temperatures and relative humidity are not available. It uses default values of moisture recovery at night based on climate classes and yesterday's 100-hour fuel moisture content. It then computes a boundary condition that is used in computations of 1,000-hour fuel moistures.

COMMON BLOCKS USED: /OBSERV/

SUBROUTINE M1000(BNDRY,MC1000,INIT)

Narrative: This NFDRS routine computes 1,000-hour fuel moisture by using a 7-day average boundary (BNDRY) condition as a driver function in the calculations. The value for BNDRY is computed in either M100 or M100A.

SUBROUTINE MIDPT2(M,C,X,CO,J,L,L1)

Narrative: This subroutine computes the median value of an order ranked distribution by methods for large sample sizes described by Nie and others (1975). M is the computed median value, C is the cumulative frequency, X is the last class's relative frequency, CO is the sample size, J is an on/off switch, and L and L1 are upper and lower class value limits.

SUBROUTINE MODE(RF,J,ISET)

Narrative: This subroutine selects the modal class value from a relative frequency distribution. RF is the distribution, J is an on/off switch, and ISET is an option delimiter set in FUNCTION IOUT.

INTEGER FUNCTION NDEX(I,J,K,L,M)

Narrative: This function computes the vector element of a 5-way stratification adjustment vector. The stratifications are (1) aspect, (2) elevation, (3) slope, (4) canopy cover, and (5) month.

SUBROUTINE ONETEN

Narrative: This function computes 1- and 10-hour fuel moisture values from the daily fire weather observation. This routine was developed by the NFDRS and has several additional data integrity checks for use in this program.
The logic is:

Step 1: Set temperature and relative humidity adjustment factors to compute fuel bed temperature and relative humidity based on cloud cover.

Step 2: Calculate equilibrium moisture content by FUNCTION EQMC.

Step 3: If stick moisture is reported and in allowable limits, use it and calculate 1-hour fuel moisture from 10-hour value and return.

Step 4: Use regression equation to compute 1- and 10-hour values if stick moisture is not reported.

Step 5: Return to CMPUTE.

COMMON BLOCKS USED: /OBSERV/

SUBROUTINE OPTFIX

Narrative: This NFDRS routine computes which processing option will be used for fuel moisture computations. IOPTIN = 1 is the preferred option and IOPTIN is the least desirable option (due to mimimal data).

COMMON BLOCKS USED: /OBSERV/

SUBROUTINE PERCOL

Narrative: This subrouitne is called by DUFF, in the case of precipitation, to compute the percolation rate of free water through the duff horizons.

COMMON BLOCKS USED: /OBSERV/, /BLOCK2/

The logic is:

Step 1: Compute precipitation rate.

Step 2: Set percolation rate as the minimum value of the precipitation rate of the hydraulic conductivity of the layer.

Step 3: Call ADSORP to compute THETA and DTHETA for the first layer.

Step 4: Adjust EMC and DMC as affected by THETA and DELTAM set SWITCH to FALSE.

Step 5: Repeat for lower layers.

Step 6: Return to DUFF.

SUBROUTINE PROFL1

Narrative: This subroutine is called by DUFF to initialize soil/duff horizons to initial season values. It is called at the beginning of each new season. The bottom layer (organic) and the lowest horizon (nonorganic) are assumed to be at fiber saturation. A linear gradient is established from the bottom layer to the surface relative humidity value.

COMMON BLOCKS USED: /OBSERV/, /BLOCK2/

The logic is:

Step 1: Set boundary layer initial conditions.

Step 2: Determine bottom layer subscript.

Step 3: Assume bottom layer (organic) and lowest horizon (nonorganic) are saturated.

Step 4: Establish linear gradients of temperature and humidity between top and bottom layers.

Step 5: Calculate vapor pressure and vapor densities of each horizon.

Step 6: Return to DUFF.

SUBROUTINE RELHUM

Narrative: This adaptation of an NFDRS routine computes the relative humidity given wet and dry bulb temperatures.

SUBROUTINE RITE1

Narrative: This is the main output subroutine for summary tables. It first calls ALPHA to change all output to a "A" format and then goes to the correct writing sequence via a series of computed GO TO statements operating on variables passed in the calling routine CMPUTE.

COMMON BLOCKS USED: /LABELS/, /SET/, /LIM/

SUBROUTINE RITE2

Narrative: This is the main output subroutine for co-occurrence tables. It first calls ALPHA to convert REAL values to an "alpha" format. It then goes to the proper entry point via computed GO TO statements operating on variables passed in the calling routine CMPUTE.

COMMON BLOCKS USED: /LABELS/, /LIM/

SUBROUTINE ROOT(NC,III,JJJ,KKK,PPP,QQQ,RRR,ADFM)

Narrative: This routine solves an Nth degree polynomial by numeric methods. The value returned in ADFM(1) is the volumetric moisture content the duff void space for solution to free water due to rain infiltration through the layers. The routine was given to the project by Michael Fosberg.

SUBROUTINE SETUP

Narrative: The call to SETUP reads user run information cards and "sets up" the run. It is called by RXWTHR. It calls INTERP and returns to RXWTHR. By reading an interpreting control card word, the program executes proper reading sequences by means of computed GO TO statements.

COMMON BLOCKS USED: /OPSET/, /SET/, /OBSERV/

The logic is:

Step 1: Read control card word.

Step 2: Interpret word from internal word file. If RUN card, call INTERP, otherwise execute proper read sequence and return to step 1.

Step 3: Compute adjustment indices if required.

Step 4: Return to RXWTHR.

SUBROUTINE SUM

Narrative: This is an intermediate computational routine for accumulating parameters needed for means, standard deviation, range, median, and frequency distribution calculations.

COMMON BLOCKS USED: /SET/, /STATS/, /OBSERV/, /OPSET/

The logic is:

Step 1: Compute month index and period number and increase value in sample size array COUNT by 1.

Step 2: Begin DO LOOP for each summary table requested.

Step 3: Set array pointer value K, based on summary parameter.

Step 4: Accumulate values for mean and sum of square computations.

Step 5: Compute interval class of summary parameter.

Step 6: Increment correct vector element of MEDIAN by 1.

Step 7: Set high and low values for range analysis.

Step 8: Continue summary DO LOOP until executed once for each summary parameter.

Step 9: If any co-occurrence tables requested, begin DO LOOP from 1 to NTABLE. Otherwise return to CMPUTE.

Step 10: Set class interval and index values for each variable in current table.

Step 11: Increment correct element of co-occurrence vector CUMCO by 1.

Step 12: Continue DO LOOP.

Step 13: Return to CMPUTE.

SUBROUTINE TESTWX

Narrative: This NFDRS routine tests each day's weather data for errors, computes relative humidity of need, and checks or computes precipitation duration. It sets some potentially undefined variables in the IOB array when used on REPEAT runs.

COMMON BLOCKS USED: /OBSERV/

FUNCTION U20FNC(SGBRT,U20,WNDFC)

Narrative: This function reduces the 20-foot observed windspeed to wind at wind flame height for calculations in ERCSC. It is called from ERCSC and is fuel bed dependent.

SUBROUTINE VAPOR(T,EWS)

Narrative: This subroutine computes saturation vapor pressure using formulas from the Smithsonian tables (Smithsonian Institution 1939). It is from the NFDRS and returns pressure in millibars.

General Overview of RXBURN

Program RXBURN computes local prescription condition frequencies based on user-defined prescription conditions. All user input (except for the number of stations to be analyzed) is read in SETUP from logical unit 5. All weather data are read from logical unit 15 in subroutine CMPUTE. All output (except for error messages) is done from subroutine MEAN. RXBURN allows up to 15 prescription factors to be entered into a prescription.

The general flow of the program is as follows:

Step 1: Read number of station to be analyzed in mainline control program RXBURN.

Step 2: RXBURN calls SETUP, which reads user control sequence. SETUP then calls subroutine INTERP to interpret user input, set program control variables and computation levels. INTERP then returns to SETUP, which then computes adjustment codes if needed and returns to RXBURN.

Step 3: RXBURN then calls CMPUTE. CMPUTE sets initial values and begins reading weather data and computing needed values as per user specification.

Step 4: CMPUTE then calls SUMMER, which tests to see if the prescription factors just read/computed constitute a preferable condiiton, an acceptable condition, or an unacceptable condition. SUMMER then accumulates values needed for mean values, run lengths, and persistence probabilities. SUMMER then returns to CMPUTE, which reads the next day's weather.

Step 5: When all weather data has been read, analyzed, and summed, CMPUTE calls MEAN. Subroutine MEAN computes all final statistics and writes all output to the printer queue. MEAN then returns to CMPUTE.

Step 6: CMPUTE returns to RXBURN to check for another station to analyze. If there is none, the program terminates normally. If there is another station, general flow returns to step 2. This is repeated until all stations have been analyzed.

In the following pages, the COMMON BLOCKS used by RXBURN are first defined. Mainline program RXBURN is then documented, followed by all other subroutines and functions in alphabetical order.

RXBURN Common Blocks

Program RXBURN uses seven labeled COMMON BLOCKS and no unlabeled COMMON BLOCKS. All values are set in the programs and none in DATA statements. The COMMON BLOCKS are defined as follows:

COMMON /BLOCK1/ : This common block is the same as /BLOCK1/ of RXWTHR.

COMMON /BLOCK2/ : This common block is the same as /BLOCK2/ of RXWTHR.

COMMON /FIRE/ : This common block is the same as /FIRE/ of RXWTHR.

COMMON /OBSERV/ : This common block is the same as /OBSERV/ of RXWTHR.

COMMON /SET/ : Values needed for the setting up and control of Program RXBURN are held in this common block. It is basically a combination of values from /OPSET/ and /SET/ of RXWTHR, plus variables needed in RXBURN.

VALUES SET : Most values in this block are set in subroutine SETUP and subroutine INTERP.

ARRAYS : DESCRIPTION

ACT(20) : Contains alphanumeric activity information (20A4 elements).

DIST(4) : Contains alphanumeric name of forest district (4A4).

FOREST(4) : Contains alphanumeric name of forest (4A4).

IRXOP(15) : Contains pointer values for extracting values from the array IOB.

LAMAT(15,2,2) : Contains alphanumeric prescription limits stratified by prescription parameter, preferable prescription (RX) minimum limit, preferable RX maximum limit, acceptable RX minimum limit, and acceptable RX maximum limit.

LIMIT(15,2,2) : Contain integer limits for prescription, stratified as in LAMAT.

NAME(4) : Contains alphanumeric user name (4A4).

NAMSTA(4) : Contains alphanumeric station name (4A4).

NRXOP(15) : Contains the order values stored in IRXOP.

VARIABLES : DESCRIPTION

ADJUST : Logical switch for inclusion of adjustment option.

ELEV : Elevation of base fire weather station (feet).

IASP : Aspect adjustment code for use when ADJUST is true.

ICOV : Canopy cover adjustment code for use when ADJUST is true.

IDAYB : Day of year to begin inclusion of days in sample.

IDAYE : Day of year to end inclusion of days in sample.

IDUFF : On/off switch that indicates if duff moisture is to be calculated.

Program RXBURN

Narrative: Program RXBURN is the mainline control program for the assessment of local prescription condition frequencies. It keeps track of the number of stations to be analyzed and the number that have been analyzed.

The logic is:

Step 1: Set run number to zero.

Step 2: Read number of stations to be analyzed.

Step 3: If at EOF, terminate the run normally. If not, continue to Step 4.

Step 4: Call SETUP.

Step 5: Call CMPUTE.

Step 6: Rewind disk file created by SAVE option (if used) and add 1 to the run number.

Step 7: Check to see if last station has been analyzed. If not, return to Step 2. If it has been analyzed, rewind weather data file, set run number to zero, and return to Step 2.

SUBROUTINE ADSORP

Narrative: Same as RXWTHR.

FUNCTION CALV

Narrative: Same as RXWTHR.

SUBROUTINE CMPUTE

Narrative: This routine is a major weather reader and computational block. It performs the exact processes that make up the balance of CMPUTE in RXWTHR, except that no statistics are computed. In RXBURN, the statistics and output are handled in subroutines SUMMER and MEAN.

COMMON BLOCKS USED: /SET/, /OBSERV/, /FIRE/

The logic is:

Steps 1 through 22 are essentially the same as RXWTHR except for two items. First, alpha input LIMIT values are DECODED to integer format, and secondly, SUMMER is called instead of SUM at Step 21.

Step 30: Call SUMMER to close out last observation strings, and ENCODE LIMIT back to alpha formats for output.

Step 31: Call MEAN and put EOF on logical unit 2 (disk file).

Step 32: Return to RXBURN.

RXBURN Functions and Subroutines

SUBROUTINE CURING

Narrative: Same as RXWTHR.

FUNCTION DECL

Narrative: Same as RXWTHR.

FUNCTION DLIGHT

Narrative: Same as RXWTHR.

SUBROUTINE DUFF

Narrative: Same as RXWTHR.

SUBROUTINE DUFFMC

Narrative: Same as RXWTHR.

FUNCTION EQMC

Narrative: Same as RXWTHR.

SUBROUTINE ERROR

Narrative: Same as RXWTHR.

FUNCTION FREEZE

Narrative: Same as RXWTHR.

SUBROUTINE FUEL

Narrative: Same as RXWTHR.

FUNCTION INDEX

Narrative: Same as RXWTHR.

SUBROUTINE INTERP

Narrative: Same as RXWTHR with changes for RXBURN.

FUNCTION IRND

Narrative: Same as RXWTHR.

SUBROUTINE M100

Narrative: Same as RXWTHR.

SUBROUTINE M100A

Narrative: Same as RXWTHR.

SUBROUTINE M1000

Narrative: Same as RXWTHR.

SUBROUTINE MAX

Narrative: This subroutine selects the maximum occurrence frequency for summary output of highest month and 10 days of frequency of prescription occurrence.

SUBROUTINE MID

Narrative: This subroutine selects quartile values of run length as called by MEAN at the right time, and sets a switch that indicates value has been computed.

SUBROUTINE MEAN

Narrative: This subroutine makes the final calculations of accumulation arrays and does all program output.

COMMON BLOCKS USED: /SET/, /OBSERV/, /STATS/, /STATS2/

The logic is:

Step 1: Set initial values and call ZERO2.

Step 2: Set total counts for seasonal, monthly, and 10-day period values, and write out first page head and prescription entries.

Step 3: Compute average number of days of each prescription type per season and compute associated frequencies and output values.

Step 4: Select highest monthly frequency of each prescription type and write them out. As many as two highest months are allowed for cases of equal frequencies.

Step 5: Select 10-day period of highest prescription frequency of each type and output. Again, up to two periods are allowed.

Step 6: Write out monthly and 10-day summaries of seasonal progression of prescription condition occurrence.

Step 7: Write out seasonal totals.

Step 8: Calculate and output mean values and quartile values of run length by monthly and 10-day periods.

Step 9: Using a simple Markov model, compute and write persistence and transition probabilities. Stratification is by month.

Step 10: Return to CMPUTE.

FUNCTION MTH

Narrative: This function sets a month pointer for use in output of the alpha month.

SUBROUTINE ONETEN

Narrative: Same as RXWTHR.

SUBROUTINE OPTFIX

Narrative: Same as RXWTHR.

SUBROUTINE PERCOL

Narrative: Same as RXWTHR.

SUBROUTINE PROFL1

Narrative: Same as RXWTHR.

SUBROUTINE RELUM

Narrative: Same as RXWTHR.

SUBROUTINE ROOT

Narrative: Same as RXWTHR.

SUBROUTINE SET

Narrative: Sets switch values for use in determination of maximum frequencies in MEAN.

SUBROUTINE SETUP

Narrative: Same as SETUP in RXWTHR with appropriate changes for RXBURN values.

SUBROUTINE SUMMER

Narrative: This routine fills the accumulating arrays contained in COMMON BLOCK /STATS/. The logic is:

Step 1: Set initial values--month number, period number, and increment sample size counter.

Step 2: Check for beginning of season (INIT) and set appropriate value as needed.

Step 3: Determine if day is "preferrable," "acceptable," or "unacceptable."

Step 4: Increment mean value accumulator arrays.

Step 5: Increment appropriate run length counters.

Step 6: Determine if prescription "type" string was broken. If not go to Step 8.

Step 7: Set appropriate run length counter arrays depending on what "type" of string was broken.

Step 8: Set counting arrays for use in Markov model.

Step 9: Set all today's values to holding value to become yesterday's value on the next day.

Step 10: Return to CMPUTE.

SUBROUTINE TESTWX

Narrative: Same as RXWTHR.

FUNCTION U20FNC

Narrative: Same as RXWTHR.

SUBROUTINE VAPOR

Narrative: Same as RXWTHR.

SUBROUTINE ZERO1

Narrative: Sets all values in COMMON BLOCK /STATS/ to zero for each run of RXBURN.

COMMON BLOCKS USED: /STATS/

SUBROUTINE ZERO2

Narrative: Sets all values in COMMON BLOCK /STATS2/ to zero for each run of RXBURN.

COMMON BLOCKS USED: /STATS2/

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Bradshaw, Larry S., and William C. Fischer.
1981. A computer system for scheduling fire use. Part I: The system. USDA For. Serv. Gen. Tech. Rep. INT-91, 63 p. Intermt. For. and Range Exp. Stn., Ogden, Utah 84401.

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KEYWORDS: prescribed fire, fire management, fire use plans, climatological data.

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The Intermountain Station, headquartered in Ogden, Utah, is one of eight regional experiment stations charged with providing scientific knowledge to help resource managers meet human needs and protect forest and range ecosystems.

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